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THE SCIENCE TEACHER

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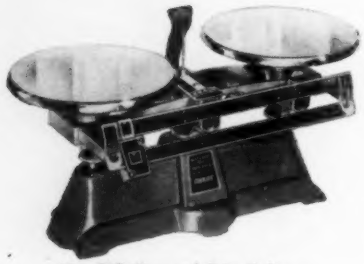
JOURNAL OF THE NATIONAL SCIENCE TEACHERS ASSOCIATION

New Model Laboratory Balances



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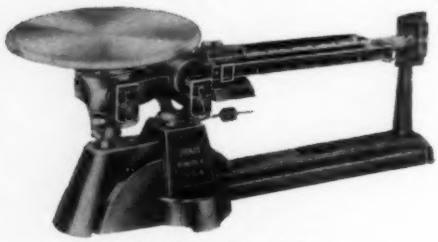

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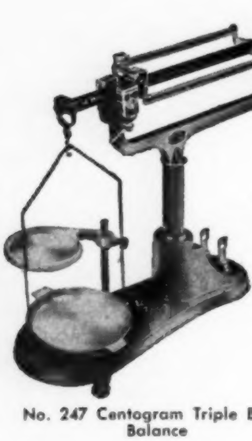

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NATIONAL INSTITUTES OF HEALTH

THIS MONTH'S COVER . . . is a picture taken during the Cancer Information Institute held October 15 at the National Cancer Institute, Bethesda, Maryland (see Editor's Column). This group of science teachers is watching a research scientist show how to prepare Rous sarcoma virus in a demonstration of a tumor-producing agent. Suitable for high school use, this experiment can demonstrate rapid and sizable tumor growth in five to ten days in the muscle of a young chicken.

Readers' Column

Loren L. Hoch in "The Use of Sponsored Films in Teaching Biology" (*TST*, Sept., 1955) states that "Educators are mainly in agreement that to be most effective, an educational film should be shown within the classroom." This sounds plausible and with younger children and to those to whom films are not an accepted part of the school routine, it is probably true.

In a large senior high school, we found the plan extremely inefficient when the change to 16mm sound films was made. Many teachers did not bother getting films and others became discouraged when they could not get the films at the requested time. Some teachers never learned to operate the projector; many forgot how between showings. The same film would sometimes be shown to the same pupils by different teachers. There was poor selection of films and a great deal of wasted time preparing the rooms and moving the equipment. There were too many projector failures due to moving the equipment and inexpert handling; rapid repairs could not be made. The whole program bogged down.

During fifteen years now, we have worked out a plan which uses a projection room with repair parts readily available and a crew of pupil operators who are quite expert. Teachers have no responsibility for the care or operation of equipment.

At the beginning of the term, along with the course of study, the teacher receives a list of films for the course and the dates they will be shown. The room is in almost constant use. At the moment there are three American History classes which meet this period in the room. Before the day is over, every class in that grade of history will have seen the film, "Winning Our Independence."

The plan lends itself to efficient management and we believe, also, that the learning value of the film is enhanced. A picture out of frame, dirt in the channel, poor sound, a long wait following a break in the film, or a burned out lamp will transfer attention of the class from the lesson in the film to the defect. We are quite proud of our system and hope that sometime the "educators" will catch up with us, the teachers.

C. VINCENT RIPPLE
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During the recent Conference on the Peaceful Uses of Atomic Energy, I had occasion to have several informal conversations with a group of Soviet scientists, and at one time we got on the subject of their training of scientists and engineers. They were well aware of the concern in this country over the declining number of such graduates and pointed out that this was not the situation in the Soviet Union. They gave as one of the reasons the fact that serious effort was made in Russia to discover and encourage young students with technical potential, through good teaching beginning at the high school level.

At the university level further encouragement to go into science and technology is assured by maintaining high teaching standards and by making the teaching profession as attractive as possible. As a means to this end, the Soviet scientists stated that university professors generally receive substantially higher pay than research workers in industry or the university. In addition, the universities frequently give their professors what we would term "fringe benefits." These benefits might range all the way from a form of special recognition having no tangible monetary value, to the supplying of homes, which has a direct monetary value.

At the high school level an effort is made to maintain a similar pay ratio between teachers and research workers, although it was thought that the actual difference in pay was not as great as in the case of university professors. From this and other information it is clear that in the Soviet Union the teaching of science in secondary schools is done by highly qualified scientists who occupy a position of esteem and importance both among their scientific colleagues and in the community at large.

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REMINDER TO TST READERS AND SUBSCRIBERS

This is the last issue of Volume XXII and of the calendar year. Publication will be resumed with the February 1956 issue. Volume XXIII will feature two new issues—May and December.

Editor's Column

The cover photo on this issue of *TST* will always remind me of one of the most interesting and fruitful one-day meetings I have attended in a long while. Two hundred science teachers from drive-in distance around Washington came to the National Cancer Institute on October 15 for a "look-see" at cancer problems and research—with a view, of course, as to how they could use in their own teaching the information, insight, and inspiration gained.

The conference started with an idea in one man's mind (not mine, though I wish it had). Planning for the affair went on over a two-month period. The planning involved research scientists, science teachers, science supervisors, and members of the NCI cancer information section. In other words, the conference was planned *with* teachers as well as *for* them.

Opening with an orientation session on the objectives and work of NCI, the teachers then heard reports from staff members on the nature of cancer research in areas of the biological and physical sciences. Then the program moved to presentations in words and color slides of experiments and projects useful for high school science classes. A dozen or more busy NCI researchers took time to look for, define, try out, and write up experiments and techniques which are actually used in cancer research and which would be suitable for adaptation and use at the high school level. From the many which were suggested, ten were presented at the conference.

After lunch in the NCI cafeteria, the teachers were divided into ten small groups and began their laboratory observation-interview visits. Each group had half an hour in each of five laboratories. This meant that the scientists repeated their demonstrations and explanations five times during the afternoon. Complete printed directions and suggestions for all ten of the experiments were given to all of the teachers. Evaluation reports coming back from the teachers indicate that these demonstrations and interviews were highlights.

The program concluded with a panel discussion by teachers of ways and means to integrate cancer information and the demonstrations into the school science subjects.

This conference, in my view, again gave evidence that science teachers are eager for new information and new ideas and techniques for making their teaching more effective. They want to know "what's cooking" on the frontiers of research and how the cooking is being done. Also, it seemed to me, this conference demonstrated an easy, effective, and inexpensive way to meet this appetite of teachers. The chief cost was the investment of time and thought by the research scientists themselves. (Of course, the teachers invested a day of their own "free time".)

Perhaps this conference can be a model after which similar conferences could be developed in and around other research centers all over the United States. There is no dearth of medical, industrial, governmental, and university research laboratories easily accessible to most of the nation's teachers.

Robert H. Carleton

THE SCIENCE TEACHER

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The National Science Teachers Association is a department of the National Education Association and an affiliate of the American Association for the Advancement of Science. Established in 1895 as the NEA Department of Science Instruction and later expanded as the American Council of Science Teachers, it merged with the American Science Teachers Association and reorganized in 1944 to form the present Association.

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*ENERGY RESOURCES

By ELMER C. EASTON

Dean, College of Engineering, Rutgers University, New Brunswick, New Jersey

THE ADEQUACY of any commodity must be measured in terms of both supply and demand. A watchmaker who possesses a barrel of oil and who uses one drop of oil a day for lubricating his watches may be said to have an adequate supply. An apartment house owner who has one barrel of oil and who needs two barrels a day to heat the building has an inadequate supply. Therefore, in order to discuss the adequacy of mankind's energy resources it is necessary first to determine the demand for energy. Much useful information on this subject was collected in 1952 by the President's Materials Policy Commission. I will quote freely from the report of this Commission as well as from other sources.

At the present time, man obtains most of his energy from oil, natural gas, and coal. Let us consider these sources in the order mentioned.

Oil

The use of oil in the United States on a commercial basis began in 1859 when "Col." Drake brought in his well in Pennsylvania. In the following year, the rather remarkable total of half a million barrels was produced. Most of this oil was used in the form of kerosene for lamps. By 1929 we were consuming 940 million barrels of oil per year, and at present we are using approximately 2.5 billion barrels per year. Before 1940 the U. S. produced more oil than it consumed. Today, however, the situation is reversed. We are now one of the largest importers of oil since our rate of consumption has increased much more rapidly than our rate of production. At the rate we are going, the U. S. demand for oil will be about 5 billion barrels in 1975 and about 10 billion barrels in the year 2000. While the demand in the U. S. is rising at this astonishing rate, the demand elsewhere throughout the world will increase even more rapidly as other nations attain our level of mechanization. Thus if the total world demand is now about 15 billion barrels per year, the demand may be 40 billion by 1975 and 100 billion by the year 2000. The adequacy of the supply must be judged in the light of this fantastic demand.

Around 1925 when people began to become concerned about the increasing use of petroleum it was estimated that the proved crude oil reserves were about 12 to 15 times the annual production. Hence it was gloomily predicted that all of the oil would be consumed in about 15 years. Fortunately, however, new discoveries and developments have constantly produced new sources so that as a result the proved reserves have continued to be 12 to 13 times the annual production during the last 30 years. There is no evidence as yet of a slackening in the

* Presented at the 1955 Summer Workshop for Science Teachers held at Rutgers University.

rate of discovery of new sources of petroleum. Furthermore, new technological developments make it possible to obtain oil from sources previously neglected, for example the shale deposits in Colorado, Wyoming, and Utah. However, it is obvious that mankind is consuming oil at a far greater rate than nature is producing it. Hence it is only a matter of time before the oil will disappear.

Natural Gas

Let us turn now to natural gas. In 1920 natural gas supplied only 4 per cent of the energy used by the U. S. By 1952 this figure had risen to 18 per cent and it is still increasing rapidly. One of the principal causes for the increase in consumption has been the development of gas pipe lines which now transport natural gas from the source to consumers hundreds of miles away.

Today, approximately 6000 billion cubic feet of natural gas are produced annually from gas wells, and about 3000 billion cubic feet from oil wells. As a rule, the dry gas wells are discovered in connection with exploration for oil wells. At present about 6000 cubic feet of recoverable natural gas is discovered for every barrel of oil. Since the energy content of 6000 cubic feet of gas is approximately equal to that of a barrel of oil, it is estimated that, as an energy source, natural gas will be equivalent to crude oil. It should be noted, however, that the usefulness of natural gas is limited by the problem of transporting it. A natural gas well in the Middle East can hardly be expected to supply gas to the U. S., although oil from the Middle East can be easily transported here.

Obviously, there is a finite supply of natural gas which will someday be consumed. The exact magnitude of the world's supply is not known, but it is apparent that we are consuming gas faster than nature is producing it and that, therefore, we will reach an end to the useful supply.

Coal

The role of coal as an energy source in the U. S. has been varied. In the 1920's this country consumed approximately 600 million tons of coal per year. At the present, the rate of consumption is only about 500 million tons per year. Thus while our total consumption of energy increased about 60 per cent, the consumption of coal fell some 16 per cent. The reasons for this decline are numerous, but the principal causes are the relative difficulty of using coal as compared with other fuels, the increasing cost of coal, and the uncertainty of the supply (the last being the result of labor strife). As every homeowner knows, it is easier to heat a house by oil or gas than by coal. There is no dirty coal bin and no ashes to take out. A homeowner will use coal only if the cost is much lower than that of oil or gas. The same thing is true in industry.

Looking ahead, however, it is evident that the use of coal will increase again. Technological developments will make it possible to convert coal economically into liquid and gaseous fuels. It is also likely that a more enlightened labor leadership will provide the essential stability for the coal industry. Thus as the supplies of oil and natural gas dwindle, it will be possible to depend more and more on synthetic fuels prepared from coal. It is estimated that the consumption of coal throughout the world will increase about 60 per cent by 1975. By that time the annual world consumption may be about 2.7 billion tons. By the year 2000 this may rise to 6.8 billion tons per year. The total reserve of coal in the world is estimated to be 6250 billion tons.

Making reasonable guesses as to the rate and extent of the discovery of new sources, and as to the increase in demand for energy, it is apparent that we may expect the world's oil and gas to last about 100 to 300 years and the coal to last about 1000 years.

It is apparent, of course, that no person living today will be inconvenienced by a lack of coal, oil, or gas. However, it is equally obvious that unless we begin now to develop new sources of energy, mankind may have to abandon its mechanized civilization.

Now, of course, there are some people who would applaud a return to the "good old days" when there were no machines and when the pace of life seemed to be slow and easy. Actually, however, a return to a non-mechanized existence would involve a loss of life far greater than that which could be caused by the most terrible atomic war. People today depend for their lives on mechanization and hence on the use of energy. For example, a century ago 85 per cent of the American people had to work on farms to supply the necessary food and clothing. Today only 13 per cent of the American population, aided by machines, work on farms. With machinery to aid in producing food, clothing, medicine, and shelter, the world can support a much greater population than could exist with food labor alone. As a result, the world's population is increasing at an incredible rate. One seventh of all of the people who have ever been born are alive today. In the next thousand years the world's population may be enormously expanded, and most of the people will be completely dependent on machines, and hence on energy, for their lives. Thus

a loss of all energy sources would result in the death of countless millions of people. We would certainly be remiss in our obligation to posterity if we did not begin now to search for the necessary new sources.

Energy Needs

It would seem wise at the start of this search to have some idea of the magnitude of our energy needs. Let us consider the problem as it affects only the United States. In 1950 the United States consumed in the form of water power, coal, oil, and gas a total of approximately 3.5×10^{16} or 35 quadrillion BTU. (In 1900 the total was 8 quadrillion BTU.) This energy was used for heating our homes, running our automobiles and farm machinery, supplying light and power, and carrying on the countless activities with which we are all familiar. If we continue to increase our use of power as rapidly as we have during the last fifteen years, we shall use approximately 80 quadrillion BTU in 1965. It is not unreasonable to expect that we will need about 300 quadrillion BTU per year one hundred years from now. Of course, it is to be assumed that in one hundred years we will have machines which will use fuel much more efficiently than do our present devices. However, even taking into account greatly increased efficiency it seems necessary to anticipate a need for 300 quadrillion BTU per year by the year 2055.

Power and Energy Sources

In order to attack the problem of obtaining power for the future let us first consider the major sources of power and the sources of energy for obtaining that power. One of the earliest sources of power used by man, and still in use today, is the work animal. Animals of all sorts have been used to carry goods, pull plows, operate mills, and perform countless other duties. Let us see to what extent the use of animals could fill our power needs in the future. We can get a fair idea of the animal power situation if we consider the possible use of horses in the United States. It takes approximately one acre of good farm land to feed a horse for one year. It would seem reasonable to expect a horse to do not more than 1500 horsepower hours or 3,820,000 BTU of work in a year. Let us make the absurd assumption that the entire farm area of the United States (approximately one billion acres) be used for raising horses. We could then get from these animals a maximum of one billion times 3,820,000 or 3.82 quadrillion BTU of work. This is about one and a quarter percent of the anticipated need a century from now. Thus, unless much more efficient animals can be produced by selective breeding, we can not get along with animals alone!

A second old and important source of power is the hydraulic engine, either in the form of the water wheel or the more modern hydraulic turbine. At present the United States has an installed generating capacity of about 17 million kilowatts in hydraulic machines which generate approximately 0.3 quadrillion BTU per year. It seems unreasonable to expect that this capacity could be increased by a factor of more than ten even if we use the power of tides, unless there should be a very large and unexpected increase in annual rainfall. Thus one hundred years from now a maximum hydraulic power capacity of 170 million kilowatts might be available. If there were enough water to run these plants at the present rate, they would generate 8 quadrillion BTU per year. This would be only about one per cent of the probable need.

The major source of our power today is the heat engine in its many forms such as steam engines, gas turbines, internal combustion engines, and jets. At present these engines are operated almost entirely on coal, oil, and petroleum products and gas. Wood and other agricultural products such as alcohol are used to a limited extent. Let us see what will happen to the heat engine when the reserves of coal, oil, and natural gas have been consumed. We might consider the possibility of burning wood or other plants in the steam boilers, and we might think of converting agricultural products to alcohol or other liquid fuels. In view of the fact that we are now depleting our forests very rapidly to obtain wood for purposes other than fuel, I think that we can rule out the possibility of supplying our power needs by burning wood obtained from full-grown trees of the forests. It is much more probable that we shall be able to use liquid or solid fuels made from some rapidly growing agricultural crop or young trees. Let us assume that we plant the entire billion acres of farm land in the United States with a crop which can be used for fuel. Assume also that this crop yields about two tons of organic matter per acre per year which is about the average figure for corn. If every bit of this material were collected and burned in steam boilers, the heat released would be approximately 28 quadrillion BTU or 9 per cent of the amount needed one hundred years from now. Conversion of this crop fuel into alcohol or some other liquid fuel before burning might make the utilization easier but would not add to the energy available; in fact, some energy would be used in the conversion.

If we keep in mind the rather obvious fact that heat engines run on heat we are led at once to

consider the possibility of using some of the natural sources of heat such as volcanoes which bring up heat from below or the sun which showers us with heat from above. Although volcanic heat is now used to generate power, the scarcity of volcanoes makes the general use of this source of energy rather unpromising! On the other hand, heat from the sun is available in varying degrees everywhere on the earth. Taking an average over the entire country, the United States receives approximately 3×10^{10} BTU per acre per year. The whole country (some two billion acres) thus receives about 6×10^{19} or 60,000 quadrillion BTU per year. This is 200 times as much energy as we are seeking for the people of 2055. (Only about 2 quadrillion BTU of this energy from the sun would be needed for food.) If we could only find some way to use 1/200 of the energy which the sun gives us, we would have solved our immediate problem. One obvious method of utilizing the sun's energy is by means of huge mirrors or reflectors to focus the rays of the sun on boilers in which water, gas, or molten metal can be heated to operate an engine. Unfortunately, even if the conversion of solar energy to useful heat were 100 per cent efficient, this method would require something like ten million acres of reflectors to supply all of our needs. This is an area about twice that of the State of New Jersey. It is probable that such vast reflectors would be used only as a last resort although small units will undoubtedly be built. As a matter of fact, solar units for heating homes may become quite popular in the near future. In one such domestic unit which has been built into an experimental house in Massachusetts, sunlight is admitted through a glass enclosure forty feet long and twenty feet wide. The sunshine heats a large quantity (20 tons) of Glauber's salt, a hydrated form of sodium sulfate. During the daytime the temperature in the enclosure rose above 91°F. at which point the sodium sulfate gives up its water of crystallization. At night, if the temperature tends to drop below 91°F. the sodium sulfate takes on the water again and gives off heat, thus keeping the material at a temperature near 91°F. Air circulated around the containers of sodium sulfate keeps the house warm day and night. This problem of storing the sun's heat for use during the night offers a serious obstacle to the development of solar energy machines of large size.

Another very old source of power is the wind. For many centuries man has used the wind to propel his ships and to operate his mills. In recent years serious studies have been made on improved types of wind machines. One such machine tested in Vermont a few years ago was an improved windmill of the propeller type. This mill, which incorporated the latest developments of the aircraft field, could generate 1000 KW of electric power. These experiments showed that wind machines can generate electricity almost but not quite as economically as the conventional steam plant. However, if wind power is to be used extensively, the problem of storage of energy will have to be solved. In the solar heating system, the heat can be stored in solids or liquids or in chemical reactions so that power is available when the sun does not shine. Perhaps some of the energy from a wind generator could be similarly stored as heat or as chemical energy. It would appear that the cost of a large-scale reliable wind power system would relegate this method of power generation to the "last resort" category, although continued use of small units is probable.

Returning to the heat engine, let us consider a source of heat which has become available to mankind within the last few years. This is the heat from a nuclear reactor or atomic pile. As everyone knows from the vast amount of material which has been written about the atomic bomb, certain radioactive isotopes of some heavy metals such as uranium-235, uranium-233, and plutonium-239 can be made to produce a chain-reaction type of disintegration. A neutron fired into the nucleus of one atom causes the nucleus to split into two or more parts with the release of more neutrons. These neutrons strike other nuclei and continue the process. Under certain conditions the disintegration of the atoms is so rapid that an explosion results. This gives us the atomic bomb. If certain absorbing materials such as boron or cadmium are interleaved with pieces of uranium and graphite, the chain reaction can be slowed down so that the disintegration of the uranium can be carried out at any desired rate. When the uranium atoms split apart, the pieces which remain have a smaller total mass than the original atoms. The difference in mass is accounted for by the liberation of energy, much of which occurs in the form of heat. This heat can be used to operate heat engines just as we now use the heat from a coal fire. The interesting difference between the two fuels is in the amounts required to produce a given quantity of heat. The disintegration of one pound of uranium-235 produces as much heat as the burning of 2,272,000 pounds of coal. If we were to obtain the desired 300 quadrillion BTU per year from the release of heat from uranium fission, we would require the expenditure of only 5000 tons of uranium-235 per year.

(Please continue on page 286.)

REFLECTIVE THINKING as a PURPOSE in high school science

By WILLIAM N. JACKSON
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Present Status of Science

MODERN RESEARCH IN SCIENCE has resulted in many remarkable discoveries which have added to the comforts of living in our world. In the medical field alone the many instruments and drugs used today in the combating of disease have relieved suffering tremendously and virtually eliminated many diseases which were the scourge of humanity during the nineteenth century.

The transportation industry has not only made accessible distant points on the globe but has also enabled passengers to travel with much the same comfort enjoyed by one leisurely reading in his own living room. "Breakfast in New York and dinner in London" is no longer a goal—it is a fact.

These two examples of progress made through science were not achieved haphazardly or through the blessings of "Mother Luck." They, as well as other advances, were brought about through procedures worked out premeditatedly and with these goals visualized. Research workers usually have a pretty definite notion of what they are looking for and secure their notions and the plans for realizing them by use of a thinking process—the process of reflective thinking.

On the other hand, the use of many products realized through science has not been grasped clearly by many people. In spite of the competence of medical workers, there are many who value the advice of quack practitioners and follow current fads promoted by manufacturers of vitamin tablets, laxatives, and "tonics." And too many people are without the benefits derived from medical research. Although the automobile has evolved to its present state of mechanical efficiency through concerted efforts of automotive engineers who profit from the data secured from accidents and from proving ground tests, we continue to make the automobile a dangerous vehicle, as the mounting total of human life exacted through its use demonstrates.

Despite the knowledge and information which has been disclosed by biologists and psychologists concerning sex and reproduction, there were 7838 rape crimes committed in the United States in 1953-54. Thirty-seven percent of them were committed by persons under 21 years of age.[1]

In our preoccupation with developing physical resources we have not given much thought to our use of these inventions and discoveries. The problem of changing our beliefs with respect to the "stigma" of tuberculosis and venereal disease must be considered equal in importance to that of the discovery of cures and preventives, if we would eliminate the diseases. The problem of arriving at sound beliefs with respect to the operation and use of modern vehicles and other appliances can and should be approached reflectively, just as the problem of improving their efficiency was approached reflectively.

These observations are pertinent especially to the school, our agency for training the young to fit into, and to improve, society. The school, along with parents, the church, and other agencies, is responsible for the medieval outlook of the lay citizen on the distribution and consumption of scientific discoveries. Students—those in training for industry as well as for other fields—have been trained to believe that the reflective process belongs solely in the realm of science. By the "sin of omission," the student, now a citizen, attacks problems of social

[1] Federal Bureau of Investigation, *Uniform Crime Reports for the United States*, Annual Bulletin; Vol. 24: 110, 1953; Vol. 25: 112, 1954.

significance through unpremeditated trial and error, without reflection, and through fallacious and unfounded beliefs.

In many instances, the school takes one or the other of the following positions:

> One of these positions is based on the doctrine of "mental discipline"—the assumption that resourcefulness of mind, or the ability to bring previous experience to bear on new situations, can be trained through exercise in such logical disciplines as are provided by the ancient languages and mathematics. Under the influence of this belief the sciences have been taught deductively and with emphasis on their logical organization with a view to training in an ability which, it was assumed, would "transfer" or come into play in quite different kinds of problems. The other position denies the practical effectiveness of this procedure and assumes that students must be given specific training for the specific situations in which they are likely to find themselves.[2]

One position recognizes the need for students to have good thinking techniques, but too much is left to chance and the position is based on unfounded beliefs. The principal belief is that the absorption of factual information by the student will improve his thinking abilities. It is true that thinking is enriched through facts, but mere possession of facts does not guarantee the possessor the ability to use and apply them to pertinent situations. Too, factual knowledge represents only one aspect of the thinking process. The decision to build up this aspect, while neglecting completely the other of the process, has resulted in a citizenry who do not possess the skills necessary for clarifying perplexing problems which require active thinking rather than recall of pertinent facts.

The second position takes the "worm's eye view" of problem-solving. Here the assumption is made that the thinking process is different for specific tasks. This viewpoint hampers the student because he never reaches the stage for generalizing his information, for seeing its relation to the more pervasive problems of living. The stamp of specialization restricts the student's ability to solve problems in situations which do not involve the skills and understandings related to his job or profession.

The Need for Reflective Thinking

MAN DIFFERS FROM OTHER ANIMALS because of his ability and because of numerous factors—both innate and external—which inhibit it. Thinking represents the totality of mental processes taking place each day as well as the past experiences of the individual. And the quality of one's thinking determines the degree to which one leads a satisfying ability to use reflection in solving problems which confront him. However, not all men can utilize the life in society. So many persons lead an uneasy and uncertain life because of the faulty decisions which they reach, the decisions being conditioned by past experiences which neither stimulate nor serve as proper guidance for thinking.

The job of the teacher, then, is to approach the pupil with one purpose in view: to provide opportunities for students to exercise and develop their ability to do reflective thinking. There are other purposes but each is subordinate to, though in support of, the development of thinking abilities. These subordinate purposes are actually the "means" for attaining the "end," whether they be learning to express oneself, to read, to acquire desirable traits of personality, or to attain skill in computation with numbers.

A third position, not generally taken by schools, considers the desirability of developing pupils who will have and use reflective thinking habitually on *any* problem with which they are confronted. The promoters of this position assume that the objective can only be achieved when the classroom experiences of pupils are sufficiently varied to give them some experience with problems of the type that they will encounter in life. Zechiel and McCutcheon list the following assumptions as basic for this approach to education:

1. The future knowledge-needs of adolescents are not accurately predictable.
2. There is a continual and increasing need for intelligent thinking in every aspect of life, personal, social, and economic.
3. There is a continual and increasing need for social concern and skills in social participation.
4. We suffer and will suffer from too great specialization.
5. Intelligent thinking, social concern, skills in social participation, and rich, many-sided personalities do not result from transfer, but have to be sought as directly as possible.[3]

All persons concerned with the process of reflective thinking agree that an important beginning phase is "a sense of perplexity, or of want, or of being thwarted, followed by identification of the problem."[4] This description carries the implica-

[2] Commission on Secondary School Curriculum, Progressive Education Association, *Science in General Education,* New York: D. Appleton-Century, 1938, p. 307.

[3] A. N. Zechiel and S. P. McCutcheon, "Reflective Thinking in Social Studies and in Science," *Progressive Education,* 15:285, April, 1938.

[4] Commission on Secondary Curriculum, *op. cit.,* p. 309-310.

tion that reflection is not bound or limited to certain academic subjects, such as chemistry, biology, or physics, but the whole world of human affairs. From comparatively simple household problems to highly abstract problems in mathematics, is the prerogative of reflective thinking. Hence, the five assumptions above are appropriate guides for a teacher having a genuine desire to develop pupil abilities in reflective thinking.

Principles Supporting Reflection

IF DESIRABLE CHARACTERISTICS of personality, including the ability to think reflectively, are to be developed, we must teach specifically for this purpose. Our choice of subject matter and teaching method must be decided upon in terms of their potentialities for developing thinking abilities. Frequent opportunities must be provided for pupils to experience phases of the process in varied situations.

1. *The reflective act is encouraged when pupils have freedom to formulate or define their own problems.*

The reflective act is engaged in habitually by the inventor and by the research worker. They are confronted with perplexing problems of their *own* making. The interest evoked by such problems goes a long way toward providing the necessary incentive to pursue the problem to its solution. It would seem reasonable to allow pupils the same freedom to formulate problems of concern to them.

Our thinking is not compartmentalized in terms of biology, chemistry, or physics. The problems which we raise can be treated frequently from the standpoint of one of these subject areas, but a more comprehensive consideration can be made when the resources of any or all the areas can be drawn upon. The designation of courses at all grade levels by the term ". . . . grade science" or some other general title would go far toward relieving teachers of the traditional responsibility for teaching as much of the factual knowledge in a subject area as he can "cover" during the year.

The attitude of the teacher toward his pupils is another factor which influences this principle. The teacher who *alone* decides what specific problems are to be investigated by pupils stifles the initiative of pupils—a quality which is necessary for reflective thinking. The value of pupil-teacher collaboration in formulating problems has been discussed profusely in professional literature. Teachers can do much toward putting pupils at ease so that they feel free to give expression to their desires.

Types of problems suggested by the Committee on the Function of Science in General Education represent a sound basis for developing reflective thinking abilities through pupil needs. Pupils generally are concerned about problems in: (1) personal living, (2) personal-social relationships, (3) social-civic relationships, and (4) economic relationships.[5]

Such problems as the following are the active concerns of adolescents in the four areas listed above:

1. The effect of advertising on the consumer.
2. The relative merits of using patent medicines and following the specific advice of a licensed physician.
3. Decisions to be made relative to smoking or to drinking alcoholic beverages.
4. Precautions to be taken in preserving eyesight.
5. Questions related to the traits we inherit from our parents.
6. Questions related to qualifications necessary, and opportunities, for gainful employment.
7. Problems related to human reproduction and choosing a mate.
8. The desire to acquire the facts and principles in a given subject area—to advance intellectual insight.

Failure of the schools to give more concentrated attention to Problem 7 above has accounted for many of the sexual crimes committed by young people previously mentioned in this paper. In many cases, these crimes reflect a desire to satisfy curiosity. With appropriate literature, charts, and more functional experiments dealing with the growth and development of animal embryos, it is possible that the curiosity of the adolescent would de directed in desirable channels.

2. *The reflective act is encouraged when abundant resources are available for use in the solution of problems.*

There must be available, preferably in the classroom, an abundant supply of reading materials dealing with the many interests of pupils. Reference books and a wide selection of text books as well as current magazines and pamphlets would constitute the sources of information. Helping the pupil to use these materials independently would be one of the tasks of the teacher.

Laboratory manuals and textbooks which give the "answers" in the context would destroy the incentive for inquiry. This would apply also to the teacher who is a resource person for the youngster. The teacher who gives pupils too much information does incalculable damage to the development of thinking abilities.

[5] Commission on Secondary Curriculum, *op. cit.*, p. 64-345.

3. *The reflective act is encouraged when pupils have frequent opportunities to investigate all choices or hypotheses as a basis for reaching conclusions.*

Many laboratory manuals encourage the *rapid* formulation of cause-effect relationships, as, for example, the many chemical tests for identifying elements, radicals, or compounds. The test for starch consists of adding iodine solution to the substance; a purple-black coloration confirms the presence of starch. No provisions are made for suggesting the possibility of other chemicals reacting in a similar way with starch or with iodine.

According to Dewey, "Observations formed by variation of conditions on the basis of some idea or theory constitute experiments."[6] Most of our laboratory manuals, then, do not present true experiments because the element of variation of conditions is not present. Instead, by relying solely on such manuals, we are encouraging what Zechiel and McCutcheon choose to call the "cookbook" procedure in science.

If this principle is to be supported, then the teacher must abandon the preachment technique in attempting to change the beliefs of youngsters on such personal problems as smoking and drinking. Instead, he must allow pupils to suggest and consider the possible consequences of his acts in the light of medical knowledge, accident statistics, and other pertinent information.

Frequently this principle cannot be applied because of certain factors in society which operate against inquiry. For example, belief in the superstition that a frightened expectant mother will transmit to the unborn child the characteristics of the thing which frightened her might prevent a pupil from wanting to investigate questions in heredity. The teacher can do much toward helping pupils to evaluate authorities in this respect as well as on other questions.

4. *The reflective act is encouraged when there are opportunities for both individual and group appraisal of progress made on the solution of problems.*

This principle is a part of the newer viewpoint on evaluation in education. It is consistent with, and promotes, reflective thinking. The habit of self-criticism, which this principle stimulates, would offset such a habit as self-esteem which is one of the many habits that interfere with reflective thinking.

It is helpful for any problem-solver to take an inventory occasionally of his strengths and weaknesses in the projected solution of a perplexing situation. Repeating a step or incorporating changes in procedure, as a result of such an inventory, have produced the thrill which comes when the result is disclosed suddenly by a change that was apparently insignificant.

The conventional symbol grade or mark assigned by the teacher as his evaluation of pupil growth would not promote this principle. Rather, a descriptive statement of the pupil's work and study habits would help the pupil to acquire those techniques which support and improve thinking ability.

5. *Eventually, pupils should become aware of the characteristics of reflective thinking. This applies especially to pupils in the upper grades of the high school.*

Pupil awareness of the characteristics of reflective thinking should be approached gradually. They should be allowed to make mistakes, to go up "blind alleys," rather than be told that this procedure "won't work." They should have the opportunity to work over facts, many of which have no direct bearing on the problem under consideration. They ought to have the chance to examine their failures critically in order to learn through these failures. The experience of selecting data—the information relevant to the problem—would help in developing an awareness of the characteristics of good thinking and an appreciation of the potentialities of the process.

These principles and assumptions to which we subscribe should enable the science teacher to have an active part in training young people to assume leadership roles in attacking problems of living in their own home circles and in their wider contacts with society. Conceivably, pupils would leave the high school with an appreciation of the part that the school has played in their development, rather than belittle its contributions.

[6] John Dewey, *How We Think*, Boston: D. C. Heath and Company, 1933, p. 197.

THREE TIMELY REMINDERS: (1) the 1955 convention of the Central Association of Science and Mathematics Teachers will be held November 25-26 at the Sheraton Cadillac Hotel in Detroit, Michigan. For further information, write to Dr. Milton O. Pella, *President of CASMT*, University of Wisconsin, Madison.

(2) It's time to send for entry materials for seniors who wish to enter the 1955 Westinghouse Science Talent Search.

(3) It's time to start planning for student participation in the 1956 National Science Fair, to be held next May in Oklahoma City.

Talent Search and National Science Fair information available from Miss Margaret E. Patterson, Science Clubs of America, 1719 N St., N. W., Washington 5, D. C.

SCIENCE DEMONSTRATIONS FOR IMPROVED LEARNING*

By ROBERT STOLLBERG
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"DEMONSTRATION: (1) the method or process of presenting or establishing facts; (2) the procedure of doing something in the presence of others either as a means of showing them how to do it themselves or in order to illustrate a principle, for example, showing a group of students how to set the tilting table on a circular saw or performing an experiment in front of a class to show the expansion of metals under heat." So reads an authoritative sourcebook on the meanings of educational terms **(1)**.

It shall be the burden of these pages to broaden teachers' concepts of what science demonstrations are and what pedagogical results can be derived from them, and to help the teacher use demonstrations more effectively.

There are many recognized functions which classroom demonstrations in science can and do serve **(2)**:

(a) *To illustrate a principle or a fact.* Demonstrations may be used to help students acquire knowledge since they reenforce verbal and other more abstract means of communication. As such they may be used for initial learning or for review. When so used, demonstrations may be said to help students learn subject-matter, in the more limited sense of the word. This is probably the most common use of science demonstrations in today's public schools.

(b) *To visualize processes.* Frequently the facts or principles incorporated in a demonstration are actually processes or mechanisms which occur in nature or at the will of man. In such a case the demonstration is adapted to show the *functions* involved. These may cover a wide range, including biological, chemical, geological, and physical phenomena, as exemplified by demonstrations of phototropism, spontaneous combustion, erosion, and the operation of a gasoline engine.

(c) *To show materials and specimens.* Demonstrations may be structured to help students acquire visual or other sensory familiarity with important objects, substances, and samples. As such, demonstrations may range all the way from passing leaves or rocks around the class to a carefully planned, almost museum-like display of items, usually accompanied by generous verbal enrichment from the instructor.

(d) *To portray methods and techniques.* Demonstrations can be used to help students understand or learn the methods and techniques employed in the scientific enterprise. These might be methods usually used by scientists or technicians, such as the typing of blood. On the other hand, they may be techniques which the students themselves should master, such as bending glass tubing or using a microscope properly.

While this categorization by no means exhausts the occurrence of demonstrations in science classes, it does cover the vast majority of their uses. It would appear, however, that resourceful and ambitious science teachers could greatly enhance the effectiveness of the demonstration techniques by using such activities in still different ways. For example, demonstrations can also be used:

(e) *To stimulate interest.* Demonstrations can be extremely useful as means of exciting interest on the part of students. One teacher of the writer's acquaintance used to inaugurate his physics classes with a *series* of brief demonstrations, each illustrating a change of energy from one form to another. The class was asked merely to observe to see what the teacher's activities had in common. This sequence was performed in utter silence, with the teacher deliberately trying to create an atmosphere of suspense. This demonstration and the discussion which it inspired not only provided an excellent insight into the scope of physics, but strongly stimulated student interest as well **(3)**. Another teacher liked to launch his photography class with a sensation demonstration. Prior to the first meeting of the class, a view camera, flash equipment, and other photographic paraphernalia were set up. The instructor carefully timed a punctual entry into

* An address presented July 1, 1955, to a general session of the annual NSTA summer conference held at the University of Wisconsin.

the room. Immediately and without a word he fired his pre-installed flash bulbs and took a picture of the astonished class with his pre-adjusted camera. Thanks to special low-sensitivity film and paper, he then proceeded to develop and print the picture. In this way he not only suggested to the class the scope of the course, but also aroused their profound amazement and insistent curiosity. These are but two examples of the use of science demonstrations as a means of developing student interest **(4)**.

(f) *To create a problem situation.* Demonstrations may be used deliberately to present a challenging problem situation to the class **(5)**. A particularly well-known science teaching activity serves as an example **(6)**: During a consideration of the oxygen content of the atmosphere, it is common practice to extinguish a candle under a milk bottle or similar container. If the candle is first mounted in a shallow puddle of water, the liquid will rise part way into the bottle after the flame is extinguished. (It is commonly thought that it will occupy about one-fifth of the volume of the bottle, thus indicating the approximate oxygen content of the atmosphere.)

Actually, and for a variety of reasons, this procedure yields singularly unreliable results. To the teacher who expects this activity to provide hard and fast experimental evidence to support his and the textbook's authoritative pronouncements, this situation comes as something of a shocking disappointment. On the other hand, those who are familiar with the nature of this activity can develop its inconsistent results into a baffling and challenging situation to science students. From it, enterprising teachers can work out an excellent sequence of investigative activities for the class. Instructors who take seriously the development of problem-solving ability as an objective of science education will find this a particularly valuable use for a demonstration.

(g) *To find information.* Demonstrations are by no means confined to functions of illustration and stimulation. Like good laboratory situations, they can serve as means of seeking solutions to selected problem situations. This was the case when a student once asked if it is really true, as she had heard, that water swirls down the drain always in one direction in the northern hemisphere and in the opposite direction in the southern hemisphere. The class as a whole showed plentiful interest, a paucity of information, and a variety of opinion on the matter. Taking advantage of this problem, the teacher arranged a demonstration to investigate the issue. This was done with several laboratory sinks, a photographic wash-tray, and a nearby drinking fountain. These sample situations produced inconsistent results, so the students carried the challenge of the demonstration home to a variety of plumbing installations. The next day they pooled their observational results and arrived at a tentative statistical generalization to cover the situation.

This is cited as an example of using a demonstration as a means of seeking information. The fact that it was followed by individual student investigation at home is commendable, but momentarily beside the point. The record fails to show whether or not the teacher was aware of what the outcome of this investigation might be. If he was not, he should be commended for his frankness and his willingness and ability to organize a suitable investigative procedure. If he did know, he can scarcely be condemned for having at least implied an extremely mild misrepresentation.

(h) *To evaluate student achievement.* Demonstrations can be modified so as to provide excellent vehicles for the measurement of science learning. A teacher can present a demonstration (with or without comment) and ask students to observe it, interpret it, or comment on it. He may deliberately misperform certain techniques or arrive at unsound conclusions, requiring that students be alert to identify his misdemeanors. Such evaluation can be adapted to either oral or written response. It should be noted that it lends itself not only to the evaluation of science *content*, but to the *methods*, the *attitudes*, and the *skills* of the scientific enterprise as well.

Any science teacher—novice or veteran—can always use new ideas for demonstration activities. Yet it is not the function of these pages to provide specific suggestions, nor even to compile resources where they may be found. Such listings have been well provided in a number of places **(7)**.

In general, writers have been more productive in turning out activity collections at the elementary school science level than at that of the secondary level. However, high school science teachers need not be utterly discouraged at this situation. Actually, typical elementary school science activity collections often contain many pertinent suggestions for use in the junior and even the senior high school **(8)**. For one thing, some writers frequently "miss the mark" and include in such collections activities which exceed the maturity level of grade

school youngsters. For another, it frequently happens that students reach high school science classes without having been exposed to science experiences which may be entirely appropriate for pre-adolescent children. When this is the case, the secondary school science teacher may very properly include such elementary activities. Indeed, these adaptations would be more educationally sound than introducing such students to science on an out-and-out high school level.

The professional literature of science teaching, particularly textbooks for prospective science teachers, abounds with "rules and regulations" for effective science demonstrations. Such admonitions as:

"Keep them simple and brief."

"Rehearse them carefully in advance."

"Have materials ready before class."

"Be sure the students are thoroughly prepared for what they will see."

and

"Store materials as a unit pending the next performance."

seem to be as traditional and established a part of science demonstrations as does the demonstration table itself. In general, such advice is sound, particularly for the "showing" or "illustrating" type of demonstration—and particularly in situations where it *can* be followed.

However, if the role of the demonstration in high school science teaching is to be expanded as suggested on previous pages, at least some of the "eternal verities" as well as certain persistent problems about their presentation must be reexamined:

A. Must demonstrations always be thoroughly prepared?

In general it cannot be denied that a well prepared demonstration is superior to one with which the teacher has had little or no experience. Yet if advance preparation is accepted as an inviolate rule, spontaneous demonstrations of the type suggested above are eliminated from the teacher's repertoire. Every science teacher knows that there are occasions when demonstration rehearsal is a practical impossibility. Should demonstrations be scrapped under these all-too-common conditions? Often a teacher "gets an inspiration" for a demonstration right in the middle of a teaching situation. If the time is uniquely ripe for the activity, should it be sacrificed because there is no opportunity for meticulous preparation? Frequently (and the more frequently the better) students come up with an idea for a good demonstration—a "What would happen if . . . ?" Should these "high adventure" experiences of scientific thought be spurned because by their very nature they preclude careful rehearsal?

NO! There is plenty of room for the *spontaneous demonstration* in good science teaching. This is particularly true where the activity is intended primarily as a problem-posing or an information-seeking teaching technique [as in (f) and (g)].

It is quite evident here that the role of the classroom demonstration overlaps that which is often associated with the science laboratory experiment. The implication is deliberate, and will be discussed later.

B. Must demonstrations be brief?

Brevity is the soul of wit, and often of pedagogy as well—but not always. Some activities simply do not lend themselves to a "short exposure." Demonstrations of diffusion of gases, rusting of iron, or osmosis require hours or days; those involving the growth of living things may take weeks, months, or even years. Surely, a demonstration should be brief—but not so brief as to have no value. And the necessarily long ones should not be discarded from the science teacher's professional bag of tricks.

Again it is apparent that classroom demonstrations and laboratory experiments have much in common—this time recommendations for longevity **(9)**.

C. Must students be prepared for demonstrations?

If "preparedness" means "readiness," then it follows that students should be prepared for a demonstration in that it should not be presented until the time is ripe. Again, in the case of demonstrations designed to teach a principle or illustrate a technique, they are usually more effective if students are aware of what they are about to see. But what of spontaneous demonstrations, and what of those intended to breed interest, pose problems, or seek information? Evidently the "rule" of preparing the class merits a reexamination in this broader concept of science demonstrations.

D. Must demonstrations be presented by the teacher?

When teaching activities involve an element of danger, they should be done by the teacher whose experience minimizes the liability. It is probably best for teachers to do the manipulation when difficult techniques are involved, or when highly skilled pedagogy is required to make the concepts clear or bring out the implications of the activity. But is

(Please continue on page 289.)

Developing Science Atmosphere in the Elementary Classroom

By ROBERT H. COOPER

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TODAY, as on many days, my students and I have returned from visiting elementary classrooms in a number of schools. The teachers and the pupils vary, but one thing we notice in general—some classrooms give us a refreshing feeling of joy and happiness while others leave us with a feeling of blankness and depression. This is not due to the fact that some of the school buildings are new and some are quite old. What is the reason? What are some of the things we see and what are some of the things being done?

Many rooms have aquaria and terraria which add much color and life.

There are some general rules that should be followed in making successful aquaria. The container may be any clean jar, such as a fruit jar, a gallon mayonnaise container, or a paste jar. It seems unwise to spend large amounts of money for a container when only simple equipment is needed. Some of the simple rules to follow are:

1. Use a small amount of animal life in the aquarium and tend to overdo the underwater plant life. A conservative procedure is an inch of animal life to a gallon of water. That would be an inch of fish from tip to tip.

2. If it is a tadpole aquarium use algae in the water for food. The tadpoles do well on it.

3. If the water becomes milky in color something is probably wrong. One of the best ways to test is to smell the water. Its odor should be that of a clean pond.

4. When cleaning aquaria do not use abrasive materials such as scouring powders, steel wool, or razor blades. Use vinegar and water or soap and water, and if necessary a stronger acid than vinegar. Then wash the aquarium out thoroughly and rinse it many times.

5. Caulking compound may be used successfully to repair leaks in certain types of aquaria.

6. Avoid overfeeding. Fish and other animals are often overfed rather than underfed.

7. Keep the aquarium covered with a piece of glass.

8. Native fish are very interesting in aquaria but the number must be kept very small. It is fun to have an aquarium with just tadpoles and plenty of algae. It is also interesting to have other aquaria with native fish or with the "store" fish.

Some of the simple rules for making the terrarium successful are those found in the rules for building aquaria. The container again may be most any type. Some of the rules to follow are:

1. Keep down the animal life if the plants are to look fresh and erect.

2. A layer of charcoal may be used at the bottom of the terrarium to help keep it from souring.

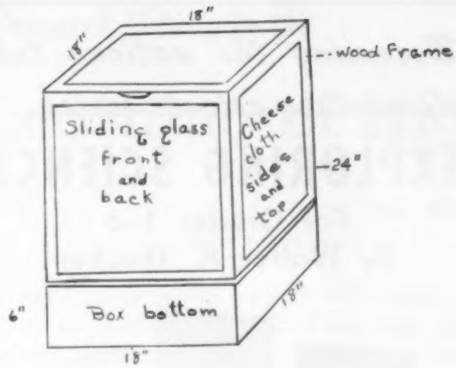
3. The materials should fit the container. Small plants do well. The mosses and the little plant called moneywort, along with some of the small ferns, do quite well in terraria.

Growing Plants in the Classroom

Most teachers are familiar with the growing of sprouts from a sweet potato placed in water. All through the winter much joy may also be brought to the classroom by forcing narcissus bulbs. Wide-mouthed pint jars are large enough for the bulbs to be placed in. Stones placed around the bulbs will hold them in place. The plant may then be put in a dark, cool place and kept watered. After a short period of time, when brought out into the light, it will continue to grow and blossom.

Insect Materials

Some classrooms are cheerful because of insect materials kept throughout the school year. A cage can be made which will be an asset during most of the year. The top of this insect cage is a frame about 24 inches high, 18 inches wide, and 18 inches long. The top and two sides are covered with cheesecloth or some other thin cloth. The front may have a piece of glass that slides up and down; the back may have either a stationary piece of glass or cheese cloth. The top part of the cage just described, is placed on a box about 6 inches high, 18 inches wide, and 18 inches long. The box has a wooden bottom. This makes a good container for soil. A jar of water may be placed in the soil and



branches placed in it in the fall or in the spring when caterpillars are brought in by children. It is possible to put a string or a wire across from one corner to the other of the top part of the cage on which to hang some cocoons or some nests of insects, such as the hornet's nest. One should not bring in a hornet's nest while there are live hornets in it.

This type of cage makes an excellent place to put grasshoppers in the fall to watch them lay eggs in the soil. You can even raise grasshoppers in the room. Remove the egg masses that adult grasshoppers have laid and place them in sand in a tin can. The masses should be kept moist and placed in a refrigerator for from four to six weeks. After the eggs are then placed back in the cage, they usually hatch in a rather short time. In winter, cultivated dandelions available in many markets make good food for the young grasshoppers. The insects will grow rapidly. They can be watched while they molt. They can be observed when the first wing pads appear. To vary the diet, corn may be planted in small flower pots and grown to a height of four or five inches. Then the pot may be set in the cage and the grasshoppers allowed to feed on the young corn.

This type of study creates an interest which is enduring. By studying such insects as the grasshopper and the cricket, the children may see the feeding habits. It is interesting to watch the mouth parts while feeding is going on. The egg-laying process and hatching of the eggs can be observed; the growing of the insect along with the molting process is most fascinating.

Some rooms are made cheerful by butterflies in the fall. Such butterflies as the monarch and the common swallowtail can be brought right into the classroom. They will fly to some of the plants which may be growing in the room and can be caught by placing the thumb and forefinger over the folded wings. With a drop of sugar water on the tip of the finger the insect may be fed by holding the food close to the lower part of the head. With a little patience the children will see the mouth part uncoil. It will be placed in the drop of sugar water by the butterfly and slowly the drop will be seen decreasing in size. It is possible to keep butterflies in the classroom into the latter part of November and the early part of December. They almost make good pets!

Bulletin Boards

Bulletin boards add much to the classroom. It is possible to do experiments and then place them on the bulletin board in order that all may see them from day to day and try them out. The electromagnet is a simple experiment which is good to fasten to the bulletin board. It is possible to suspend the dry cells by placing a tack in the top edge of the bulletin board and hanging them by wire or string. It is possible to thumbtack a little cardboard shelf to the bulletin board and set the dry cell on that with a piece of scotch tape around the dry cell and a thumb tack in each end of the tape. By fixing the electromagnet over a bit of space, it is possible that any child who wishes to, may step up and push the switch button and have the electromagnet work by touching the nail to a little match box with iron filings in it, attached to the bulletin board.

Many other projects and experiments done in the classroom may add to the pleasure of the children and be of interest to visitors if the projects are placed in some manner upon the bulletin board to be seen over a longer period of time. Bouquets of flowers may be suspended on the bulletin board at different times of the year. The bulletin board can be used for the seasonal display of both animal life and plant life.

The photograph of *Let's Make a Bird House* is an illustration of what may be done in the way of bulletin board instructions for making a project or

as a follow-up of a project. This project is one where an oatmeal box is used. (Of course the bulletin board shows only half of the box since that is a way of mounting it for observation.) The oatmeal box has the size hole in it that would be used for the type of bird that one wishes to house; the one in the illustration is the size for the bluebird. The coat hanger is cut as shown in the photograph. The oatmeal box is painted with water paint with a little soap added to make it stick. After drying, the box is rolled in warm paraffin. The lid is done the same way. The lid is placed on the oatmeal box and the box is rolled again in the warm paraffin in order to put a coating over the entire box and lid. This causes the lid to be fastened on also. Now a little stick may be placed in the box in order that it may be hung. The stick is probably most successful when put entirely through the box through holes on either side in order that the stick may be more solid. This is an interesting project and makes a rather durable, inexpensive birdhouse.

What Does It?

What lends science atmosphere to the elementary classroom? It is the use of many little items, some seem quite insignificant, but as one visits from room to room and from building to building he comes to realize that many times the little efforts that the teacher and the pupils put forth add up to make the difference between a lively pleasant place to work and one that is drab and tiring.

Handbook for Teaching of Conservation and Resource-Use. This 450-page book recently published by the National Association of Biology Teachers was prepared by 200 teachers from 30 states and shows how they have incorporated conservation and resource-use teaching into their schools. The project was financed by a grant from the American Nature Association. The Handbook may be obtained from the office of the Project Leader, Richard L. Weaver, P. O. Box 2073, Ann Arbor, Michigan at a cost of $4.00 with a 20 percent discount to schools.

Life and Death of the Soil. This new edition to Science Research Associate's Modern World of Science series presents the story of the land and its importance to man. A 48-page, illustrated booklet written by Robert C. Sherman with Paul F. Brandwein as consulting editor. Available from Science Research Associates, Inc., 57 West Grand Avenue, Chicago 10, Illinois. Price: 60¢.

Your Life Plans and the Armed Forces. A 160-page booklet prepared under the direction of the Defense Committee of the North Central Association of Colleges and Secondary Schools, with cooperative efforts and approval of a vast number of organizations and institutions. It is written at the "grass-roots level" to help young people formulate life plans and goals; the second section is devoted to Educational Opportunities Available in the Armed Forces of the United States. Bibliography included. Available from the American Council on Education, 1785 Massachusetts Avenue, N. W., Washington 6, D. C. at $2.00. Teacher's Guide: 60¢.

A Research Study in the

Learning of High School Chemistry

By WILLIAM H. LUCOW
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BRIGHT, high school juniors will learn chemistry no matter what method they use. Slower pupils will profit more from a laboratory-centered approach than from a textbook-centered approach. These are the conclusions reached in an experimental study made on 11th-grade pupils in a Canadian high school, where "accelerated" and "non-accelerated" classes were each separated into two groups, one following the textbook and doing a minimum of laboratory work, the other doing much laboratory work and free to use any chemistry book as a reference. Thus, the experimental samples included:

1. an accelerated, textbook-centered group,
2. an accelerated, laboratory-centered group,
3. a non-accelerated, textbook-centered group, and
4. a non-accelerated, laboratory-centered group.

The first two groups, on being tested, showed almost identical improvement in average achievement and in spread of scores. The second two groups showed a difference in these measures, the laboratory group making the better showing.

The Textbook-Centered Method

In order to be realistic about the contrasting methods of teaching chemistry, the experimenter decided not to adopt an entirely textbook method but rather to *center* the learning about the textbook and still allow the pupils to do some laboratory work. The textbook used was Dull, Brooks, and Metcalfe, *Modern Chemistry* (Clark Irwin, 1951), and a special outline listed the pages to be read and problems to be attempted.

The laboratory work done by the textbook-centered groups included ten classical experiments such as mixture vs. compound, physical vs. chemical change, and determining the percentage of water of crystallization in bluestone. The pupils worked in groups of six, performed an experiment, and immediately recorded the object, apparatus, method, observations, and conclusions in a laboratory note book.

The instructor demonstrated the preparation of oxygen, hydrogen, carbon dioxide, the treatment of water supplies, and destructive distillation. (There was more to the course, but this is as far as the group went for purposes of the research study.)

The distinctive feature about the textbook-centered method was the following of the special textbook outline. Typical sequences were as follows:

(From Unit I) CHEMISTRY IN A MODERN WORLD

Read pages 4 to 8.

What are two characteristics of all matter?

Name, define, and give two examples of each of the three forms of matter.

The *weight* of a certain amount of sand is 100 grams. The *volume* of this sand is 40 milliliters. What is the *density* of this sand in grams per milliliter?

State the Law of Conservation of Matter.

What property makes it easy for us to identify ammonia?

Do Problem 1 on page 11.

(From Unit IV) THE ORGANIZATION OF CHEMISTRY

Read page 102.

Distinguish between hypotheses, theories, and laws.

Copy the five postulates of the modern atomic theory as listed on page 103.

Read page 113.

Do *Questions* 10, 16, 19, 21, 22, 23, 24, 26, 27, 28, and 29.

Study the valence table on page 120. Note that it is repeated on the page facing the inside front cover. Use the table to write the formula of sodium carbonate.

(From Unit VI) ACIDS, BASES, AND SALTS

Read pages 202 to 206.

What effect has an acid on litmus, phenolphthalein, and methyl orange?

Define neutralization and write an equation to illustrate it.

What is meant by "salt of an acid?" How may the acid be made from the salt? Give four reasons why sulfuric acid is used in the process.

Explain neutralization in terms of ion interchange to form water.

The textbook-centered groups turned in daily work sheets as they pursued their special outlines. Thus, their course consisted of:

1. working on their textbook outlines,
2. performing and recording the ten minimum experiments,
3. listening to lectures and observing demonstrations, and
4. writing criterion examinations (described below).

The Laboratory-Centered Method

The laboratory method differed from the textbook-centered method only in the matter of following the special outline. Both groups in each division were in the same room at the same time, heard the same lectures, observed the same demonstrations, and performed the same ten minimum experiments. The distinctive feature about the laboratory-centered approach was the following of a special laboratory outline. General directions and typical sequences from the laboratory outline are as follows:

Directions: Do the experiments and problems listed below, and record your results (including rough work and calculations) on a *Daily Work Sheet.* Do not do the assignments in the order that they appear on this outline, because there is not enough apparatus to go around every day. Never stop working because someone else has the apparatus you want; there is always another problem to work on. Also, do not waste time waiting for an experiment to end; a good chemist often has two or three things on the go. Consider your textbook as just another reference. The special bookcase at the front of the laboratory contains several other references for you to use. If an answer is very short, it should be entered beside the appropriate number at the right of the *Daily Work Sheet.* Long answers should be set down with due respect for the requirements of good English composition.

(From Unit 1) CHEMISTRY IN A MODERN WORLD

Find the definition of the word "chemistry" in a dictionary and in three other reference books. Write each definition with its source, and point out differences, if any, among the definitions.

Heat some ice in a test tube until the ice melts. Then, continue heating until the resulting water boils. What three forms of matter did the ice assume?

Measure a rectangular block of wood and determine its volume. Weigh the wood. Find the density of the wood.

Carefully lower a test tube containing a solution of silver nitrate into an Erlenmeyer flask containing a solution of sodium chloride. Insert a stopper securely. Weigh the entire apparatus. Now tilt the flask so that the liquids mix and a chemical reaction takes place. Weigh the entire apparatus again. Record the "before" and "after" weights.

Find the definition of the Law of Conservation of Matter in several of the reference books, and copy the one you think gives the most complete statement. Give the name of the book, the author, and the page on which you found the definition.

(From Unit IV) THE ORGANIZATION OF CHEMISTRY

Search through the reference books until you find a statement of John Dalton's original atomic theory. How does the wording of the modern atomic theory differ from Dalton's?

Compare the atomic weights of elements listed in an old chemistry book with a list in a recently published book. Is the value for oxygen the same? Find three elements for which the weights are not quite the same. How do you account for the difference?

Construct the following atoms using plastecine (modeling clay) and toothpicks. Make the neutrons very small cubes and the protons spheres. The electrons may also be spheres. Arrange the nucleus so that both neutrons and protons may be readily counted. Use ⅓ of a toothpick to attach the electrons in the K-shell, ½ of a toothpick for the L-shell, and a full toothpick for the M-shell. Bring up every atom for inspection before starting the next.

(a) hydrogen	(b) helium	(c) lithium
(d) beryllium	(e) boron	(f) carbon
(g) nitrogen	(h) oxygen	(i) fluorine
(j) neon	(k) sodium	(l) calcium

Construct the following molecules out of plastecine and toothpicks: (a) oxygen molecule, (b) lithium fluoride, (c) sulfur trioxide.

What name is given to each type of bonding in these molecules?

(From Unit VI) ACIDS, BASES, AND SALTS

Examine bottles of concentrated acids: sulfuric, nitric, and hydrochloric. From the labels find the percentage of acid, the specific gravity, and any other important facts about each.

Put a drop of phenolphthalein solution into a base solution in a test tube. Add acid until the color just changes. The reaction is called neutralization. Write the equation for the reaction, and name all reactants and products.

Carefully add a very small piece of sodium to some water in an evaporating dish. Evaporate to dryness. What is the flaky white solid left? Write the equation for the reaction.

The Criterion Examination

The chemistry test with which the groups were measured was developed the year immediately before the running of the experimental study. It consisted of three equally-weighted parts:

1. Recall of Basic Concepts
2. Application of Concepts and Principles
3. Comprehension and Interpretation

The first part called for memory of factual material. The second part consisted of problems to be solved by application of principles. The third part consisted of an experiment written up as the pupils did in their regular laboratory notebooks, and this was followed by questions that called for comprehension and interpretation of the data reported in the experiment.

The items were a novel type of multiple-response variety referred to as *The Whole Truth and Nothing But the Truth.* Thus, with four choices, one, two, three, or all four might be correct; the pupil had to choose all the correct ones and omit all the incorrect ones. The sample item read:

Example: Three times five is more than

(a) 5
(b) 10
(c) 15
(d) 20

The correct response to record on your answer slip is *a, b.* Wrong answers would be *a* alone or *b* alone. It would also be wrong to give *a, b, c* or *a, b, d.* You must find ALL the right answers and leave out ALL the wrong answers.

Some items from the test were as follows:

(From Part I) A binary compound
(a) is made up of only two elements
(b) always contains only two atoms
(c) may be an acid
(d) may be a base
Correct response was *a, c.*)

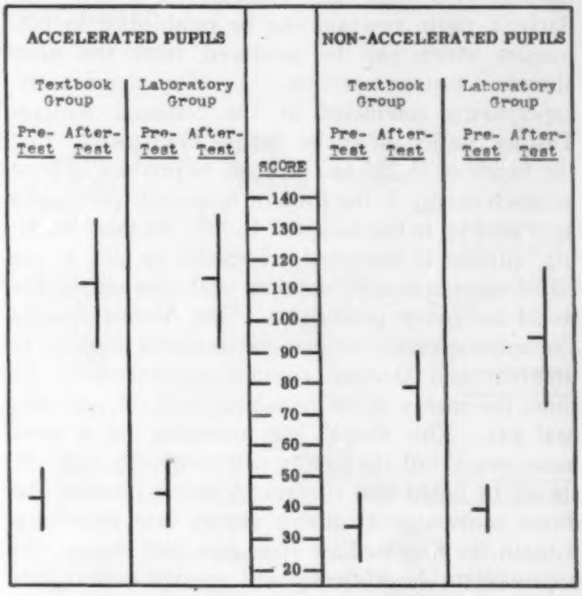
(From Part II) Seven grams of iron unite with 4 g. sulphur to form 11 g. ferrous sulfide. According to the law of definite proportions
(a) 4 g. iron should unite with 7 g. sulfur
(b) 21 g. iron should produce 33 g. ferrous sulfide
(c) 14 g. iron should unite with 8 g. sulfur
(d) 12 g. sulfur should produce 33 g. ferrous sulfide
(Correct response was *b, c, d.*)

(From Part III) (Experiment to determine the percentage of water of crystallization in bluestone.)

This experiment indicates that
(a) the percentage of water of crystallization in bluestone is about 36%
(b) the percentage of water of crystallization in all hydrated salts is 36%
(c) bluestone loses its water of crystallization on being heated
(d) all hydrated salts lose their water of crystallization on being heated
(Correct response was *a, c.*)

Results of the Research Study

The figure shows the results of the examination which was administered before and after the learning of chemistry by the two methods. The figure shows the ***mean*** (the short, horizontal stroke) plus and minus one *standard deviation* (the vertical lines) for each group for the pre-test and the after-test.



Mean ± One Standard Deviation for All Groups on the Pre-Test and After-Test of the Criterion Examination

Conclusions

The accelerated pupils did just as well with the textbook method as with the laboratory method. The non-accelerated pupils did better with the laboratory method, especially in spread of scores.

This increased spread of scores was of particular interest to the writer because he feels that great variation in classroom achievement is evidence of the expression of individual differences among pupils during the learning process. The laboratory-centered method does this better than the textbook method—at least with non-accelerated pupils.

EASTON—continued from page 272

For most common materials, 5000 tons is a relatively small amount. For example, we mine over 600,000,000 tons of coal a year. If we used U-235 for fuel we could transport the year's fuel supply for the entire nation in one relatively short freight train. Unfortunately, however, uranium-235 is a rare metal. It comprises less than 1 per cent of the natural uranium (the remainder being U-238), and natural uranium is scarce. Furthermore, U-235 is the only fissionable material occurring in nature. Before 1945, the known supplies of uranium-235 would not have been considered an important source of fuel. Since the development of the atomic bomb, however, many new deposits have been located. Fortunately, nuclear fission can be produced with other isotopes such as uranium-233. This isotope can be manufactured from the more abundant metal thorium by contact with disintegrating U-235. Similarly, a chain reaction can be established in plutonium which can be produced from the more abundant isotope uranium-238. Very significantly, experiments conducted at the National Reactor Testing Station in Idaho during 1953 proved that the fission of U-235 can be made to produce at least as much energy in the form of fissionable plutonium as is used up in the fission of U-235. As this "breeding" process is improved, we should be able to use all of the obtainable uranium and thorium in the world for power production. The Atomic Energy Commission estimates that the available supplies of uranium and thorium contain approximately 23 times the energy of our remaining coal, oil, and natural gas. This should last humanity for a good many years, but the supply will eventually end. It should be noted that if research makes possible the direct conversion of atomic energy into electricity without the intermediate stage of a heat engine, the improvement in efficiency will greatly extend this fuel supply.

An even more fascinating possibility of abundant energy lies in the development of a technique for combining hydrogen atoms to form helium. This is the process by which the sun gives off its energy. When the hydrogen atoms are combined to form helium a loss in mass results. This difference in mass appears as energy. Our scientists and engineers have already produced an explosive reaction of this sort in what is popularly called the H-bomb or hydrogen bomb. It is quite possible that someday we will be able to control the rate of the hydrogen reaction so that it may be used to develop commercial power. When that day arrives, our quest for an energy source will be over for a long time. The water of the oceans contains enough hydrogen to supply the world's needs far into the future.

Rosy as this prospect may be, we do not yet have the controlled hydrogen reaction and we must therefore continue our search for other energy sources or for other and more efficient means of utilizing the presently available sources. In addition to the use of animals, hydraulic engines, wind engines, and heat engines, there is the further possibility of obtaining power from the conversion of heat, light and other radiation, or chemical reaction directly into electricity.

Everyone is familiar with the little flashlight battery which produces electricity from a chemical reaction. Perhaps research will someday give us powerful batteries which will convert common materials into electricity by some chemical reaction at present unknown. The photovoltaic cell also deserves consideration. Every amateur photographer has seen or used a light meter. In these devices light falling on the photovoltaic cell causes a current to flow through the meter and move the indicating needle. The Bell Laboratories have recently developed a "solar battery" which consists of thin silicon strips coated with boron. Sunlight shining on this photovoltaic cell produces electricity quite efficiently. Much progress can be expected in this field. Maybe we can develop huge photovoltaic cells which will convert sunlight directly into useful electric power. The tiny thermocouple which is now commonly used for measuring temperatures should be studied more intensively. The thermocouple consists simply of two dissimilar metallic wires welded together at one end. The free end of each wire is connected to an electric meter. If the welded joint is heated while the rest of the wires and the meter are kept cool, an electric current is set up which causes the meter needle to move. Large numbers of junctions of this sort can be assembled to form a thermopile. During the last war thermopiles were used by secret agents to generate power to operate radio sets. All the agent needed to generate power was a source of heat such as a small fire, or a gas jet. Perhaps research will show the way to build immense thermopiles to operate efficiently from the heat of the sun. It is also possible that research will someday lead to the utilization of living organisms to convert the energy from the sun into a form which can be used by an inanimate machine. When man learns to obtain his energy from the sun, his dependence on exhaustible supplies of earthly fuel will end. However, the development of a satisfactory solar energy converter seems to be far in the future.

To summarize, then, we may say that man faces the certain prospect of losing his present major sources of fuel. It is certain that nuclear fission can be controlled so as to provide power from the rare uranium-235. It is fairly certain that "breeding" of fissionable material may soon make possible the use of thorium and uranium-238 as fuels. There is a chance that in the more distant future, controlled energy from nuclear synthesis may enable man to use the enormous supplies of hydrogen in the sea. Also in the distant future lies the possibility of efficient use of the energy radiated from the sun.

Since new sources of energy must be harnessed if mankind is to survive, research must be prosecuted vigorously on all possible fronts. Fear that new sources of energy *might* be used to kill men must be overcome by the knowledge that civilization as we know it will *surely* die if new sources are not obtained.

TWO SIMPLE WORD GAMES AS TEACHING AIDS

By EVELYN S. KRITCHEVSKY
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A SEARCH FOR A MEANS to provide entertainment as well as enlightenment resulted in the preparation of the following pencil and paper games involving the names of the more common elements. Both were well received by a group at an American Chemical Society Student Affiliate social affair and seem to help establish the names and spellings in the minds of freshman students. The games should also prove useful at the high school level.

A. This is a simple anagram game with the answers given below.

Scrambled Elements

Given: The name of the element written in scrambled fashion: e.g. NIT

Object: Unscrambled the name: e.g. TIN

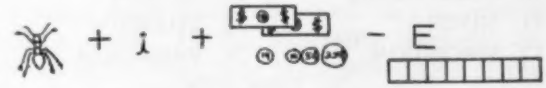
1. ANGOR	13. U MALT ANT
2. U BIM THS	14. ME ROBIN
3. I CUM MAD	15. O RICH MUM
4. HIT LUMI	16. LINE FOR U
5. CURRY ME	17. UM MINE GAS
6. IRON GENT	18. NE MANAGES
7. MUD AIL LAP	19. ONLY MUM BED
8. YON MAINT	20. PLAIN MUT
9. LON REICH	21. MISS U A POT
10. PUSH OR SHOP	22. SIC LION
11. LIVERS	23. MINUS EEL
12. O IT MUST RN	24. A MAD VUNI
	25. U TEST GNU

B. The following rebus puzzle can be traced and duplicated, this being the method used by the author. The complete answers are listed below.

1

2

3



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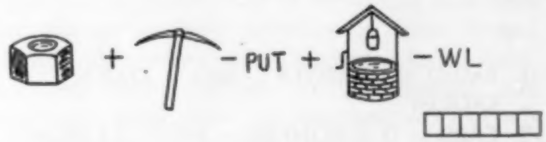

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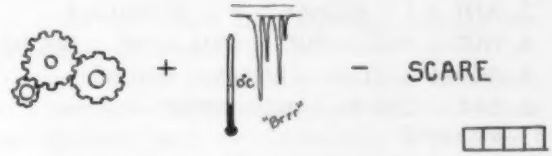

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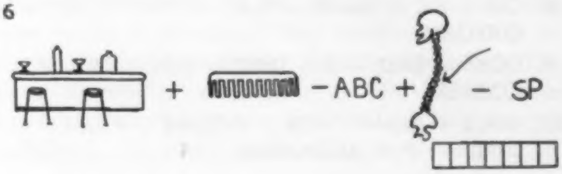

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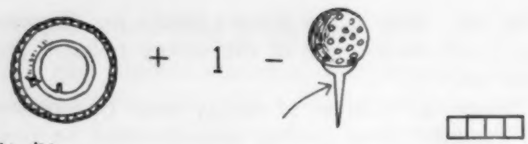

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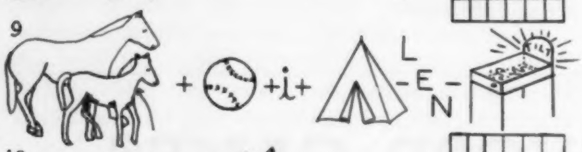

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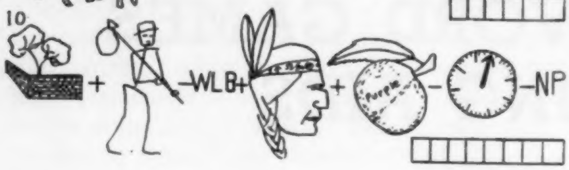

Answers

A.

1. ARGON
2. BISMUTH
3. CADMIUM
4. LITHIUM
5. MERCURY
6. NITROGEN
7. PALLADIUM
8. ANTIMONY
9. CHLORINE
10. PHOSPHORUS
11. SILVER
12. STRONTIUM
13. TANTALUM
14. BROMINE
15. CHROMIUM
16. FLUORINE
17. MAGNESIUM
18. MANGANESE
19. MOLYBDENUM
20. PLATINUM
21. POTASSIUM
22. SILICON
23. SELENIUM
24. VANADIUM
25. TUNGSTEN

B.

1. RADIO + UMBRELLA — BELL — OAR = RADIUM
2. CARD — D + BONNET — NET = CARBON
3. ANT + I + MONEY — E = ANTIMONY
4. NUT + PICK — PUT + WELL — WL = NICKEL
5. GEARS + COLD — SCARE = GOLD
6. BAR + COMB — ABC + SPINE — SP = BROMINE
7. TIRE + ONE — TEE = IRON
8. OX + FLY + GATE — FLAT + TENT — TET = OXYGEN
9. COLT + BALL + I + TENT — LEN — TILT = COBALT
10. WALL + BUM — WLB + INDIAN + PLUM — DIAL — NP = ALUMINUM

STOLLBERG—continued from page 279

this always the case? Are there not valuable educational experiences to be had by students who participate in demonstrations? Their interest and enthusiasm, their experience in expressing themselves to their fellows, to say nothing of the psychologically sound principles of purposeful activity and learning-by-doing, all indicate that there is wisdom in securing the active cooperation of students.

Some teachers like to involve as many students as possible in their demonstrations, employing them to aid by adding ingredients, throwing switches, displaying specimens, or even recording data and writing key points on the chalk-board. Frequently it is appropriate to permit students individually or in small groups to perform demonstrations for the benefit of the remainder of the class. Sometimes young people can do as good a job or better than the teacher! In any event, those students who participate in demonstrations almost invariably learn more than if they merely observe. Again it is evident that classroom demonstrations and laboratory experiments can have much in common.

E. What should be done about demonstrations that "fail" (10)?

The only teachers who have no failures in their demonstrations are those who don't do any. Sometimes failure is due to negligence; sometimes it is unavoidable. When demonstrations are spontaneous or when carried out by students, such misfortunes are particularly likely to occur. Among the worst things that a teacher can do under these conditions is to "cover up" the failure, or to try to "explain it away" and minimize its significance.

Actually, a great deal of good science education can ensue from such a situation. Questions such as "Why didn't it work?" and challenges such as "Who will undertake to study and practice and make it work?" may brighten the unhappy miscarriage of a demonstration into a radiant experience in problem-solving. Some teachers have so well learned to utilize "demonstration failures" to promote scientific investigation that they occasionally plan for "success-through-failure!"

In addition, a few other points for improved demonstration techniques may be briefly noted:

F. Demonstrations may occur anywhere.

There are no physical boundaries which confine the locale of demonstrations. They may be done in the classroom, the laboratory, in the school halls or shops, in the gymnasium or on the playing field, or "on location" during a class excursion.

G. Use real situations and every day materials where possible.

Some demonstration activities require relatively specialized apparatus. Many, however, can be done most effectively with every-day materials such as vegetables, kitchen utensils, food-preparations, household appliances, and common tools. Teachers should avoid operating exclusively either at the one extreme of exclusive use of scientific gear or at the other of perennial use of "homemade junk." One effective rule formulated by an elementary teacher is: "Why use a beaker if a milk bottle will do?—but if a milk bottle won't do, don't hesitate to use the beaker!"

H. Reports of demonstrations should be functional (11).

There is no excuse for students to submit written reports on classroom demonstrations merely for the sake of having reports. If reports will help students learn from the demonstration, or help them remember it, or serve to communicate the ideas to other students, then they serve a useful purpose and are educationally sound. Furthermore, reports may take not only the form of oral and written expression, but also graphic representations, exhibits, collections or construction projects, or even dramatic portrayal, to mention a few.

I. Integrate demonstrations with other avenues of science teaching.

There is no reason to consider the demonstration as a thing apart from other tools of the science teacher's trade. In the illustrative examples on previous pages there have been many cases of the demonstration growing out of or leading into such other science teaching activities as more formal class work, laboratory study, field trips, home work, committee responsibilities, group planning and project-type enterprises. Science teachers can utilize the demonstration more effectively if they consider it not *apart from* other learning exercises, but as *part and parcel of them*.

Throughout the preceding pages there have been strong overtones indicating that the "classroom demonstration" and the "laboratory experiment" have more in common than many science teachers suspect. Both can be contributory to much the same kinds of learning; they involve the same or similar kinds of materials; they involve nearly the same knowledge and skills on the part of the teacher. The closer these two kinds of activity are examined, the more nearly alike they seem to be.

Of course there are mechanical and administrative differences, such as requirements of time, space, and materials. But if the thoughts on the foregoing pages have validity, it can be said that the demonstration and the experiment—both avenues to learning science—differ only in these educational respects:

(a) The laboratory experiment typically provides more opportunity for individuals to manipulate equipment and materials.

(b) The laboratory experiment frequently demands more from the student in the way of resourcefulness and responsibility.

(c) The demonstration is commonly started—and sometimes carried on—by the teacher, who dominates the scene at least for awhile.

(d) The demonstration usually finds all the students in the class giving their attention to a single sequence of activities and a single train of thought. Even so, many a good science demonstration might accurately be considered as an experiment in which the entire class—including the teacher—constitutes a single large laboratory group!

As science teachers, then, we might divert some of our attention from the problem of *comparing* the demonstration and the laboratory experiment insofar as their relative educational merits are concerned. Rather we might look to improving both these teaching techniques and learning how to help them strengthen each other—laboratory experiences *and* science demonstrations for improved learning.

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EMPHASIZING THE UNKNOWN

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THE FAILURE OF LABORATORY WORK in chemistry to satisfy the needs of the students or the aims of the teachers is the result of the tendency for laboratory manuals to be written in the image of one or more textbooks. Not that this is without some value and a great deal of convenience. But it certainly is not scientific, does not give real experimental values, and leads to the evils of "cookbook" chemistry and a negation of scientific method. While cries of desperation have arisen from chemistry teachers on high school and college levels, effective solutions are still among the missing.

There seems to be a blind spot in the outlook of many teachers who have a scientific background but who cannot teach their subject to achieve "scientific" objectives. Certainly we want our students to learn techniques, but these are only part of the tactics, not the strategy, of science. What we need are miniature research problems in every experiment. We need demonstrations distinct from real experiments in which the results must remain unknowable until performed. The difficulty of showing the superiority of experimentation over demonstration may be ascribed in part to the fact that most "experiments" are not excursions into the unknown and that they are thoroughly and factually described in the textbooks from which students can obtain reliable observations and answers.

Our problems are two-fold then. "How can we teach techniques with a minimum of expenditure of time?"—and—"How can we arrange our experiments to give manipulative as well as functional experience in handling the unknown?" The answers require a reorientation in our approach to laboratory work with a new emphasis on the distinction between demonstration by the instructor and individual laboratory work by the student. This reparation is a physical one only, since a demonstration by the instructor should lead to a real experiment by the student.

The traditional "experiment" with oxygen may be used to illustrate the idea very simply. To begin with, the topic of oxygen may be introduced when the instructor performs the demonstration by preparing several bottles of the gas from potassium chlorate and manganese dioxide. He performs the typical tests with wood splints, steel wool, magnesium, etc., and concludes, after a minimum of explanation, by asking questions based on observations. So far there is little that a student has seen which he cannot get out of his textbook.

However, the student's next step in the process is to set up the identical apparatus in the laboratory and to prepare oxygen from potassium chlorate alone, or from sodium chlorate and manganese dioxide—or from five unknown numbered compounds or mixtures. He is told to heat each material in the hard-glass test tube, and then to test the gas which is collected to see if it is oxygen. Of course it is possible to introduce in this approach the concept of the negative result, as well as the single variable. The procedure may be varied so as to test other substances than manganese dioxide for their catalytic action. In each instance the intention is to introduce the principle of the unknown.

The student must perform the experiment to obtain the answers. He must observe carefully the demonstration as well as his own work to get results. Everything depends on the *experiment,* not upon the *book*. From practical experience, teachers know that students are stimulated when they work on "unknowns." Therefore, they should be used in more experiments.

It is possible to work an unknown reaction into almost every traditional "experiment" used in chemistry. In quantitative exercises, the factor is already there in the weight aspects. In descriptive exercises such as solutions and colloids, the unknown may be a quantity, an ingredient, or a type of mixture. All that is necessary is ingenuity on the part of the laboratory manual writer and industriousness on the part of the laboratory assistant* or teacher.

In setting up the three-part laboratory approach —demonstration, experiment, unknown—there is no lack of material for multiple methods of preparation, many of which are parallels or simple variants. Of course, in the latter part of the year demonstrations may be eliminated if manipulative skill has increased to the required level.

Some advantages which may be anticipated from

* Editor's note: Newark, New Jersey, is one of the few school systems we know about that still provide laboratory assistants in high school science. There should be many more!

this modified demonstration-experiment method in chemistry are:

1. The students learn manipulative skill by observing the instructor and immediately following suit in practice.

2. The experiments are motivated by inclusion of the unknowns.

3. Students get first-hand experience with variables, trial and error, and discriminating observation.

4. Facts must be obtained from observation of reactions.

5. More laboratory work can be included in the year's work.

6. Many experiments may be arranged so as to present a series of observations which may lead to a generalization; i.e., induction.

7. Working with unknowns is more stimulating than ordinary laboratory work.

8. Learning is accomplished in a variety of ways including the best, psychologically, by solving problems, and by activity.

9. Critical thinking is required in working with unknowns.

10. A maximum of subject matter may be covered in the tripartite attack.

Classroom Ideas

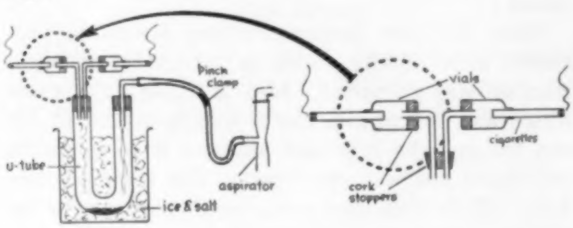
Chemistry, Biology

Demonstration of Cigarette Tars

By THOMAS P. BENNETT, Winter Haven, Florida, High School

When the cigarette-cancer scare was the fad, I decided to demonstrate some of the materials that are contained in the smoke from cigarettes.

The apparatus was set up as shown in the drawings.



A U-tube served as a collecting tube for the tars and liquids. The cigarette holders were made from small vials which had the bottoms cut off. The U-tube was held in a beaker that was filled with an ice-salt mixture. A rubber tube leading from the U-tube was connected to an aspirator. A pinch-clamp was placed on the tubing to regulate the "drags" (puffs).

The tars and other materials condensed and were collected in the U-tube. This gave a vivid demonstration of what can be found in a pack of cigarettes and consequently in your lungs. The students were, of course, cautioned against "overgeneralizing" in comparing this experimental set-up to a pair of human lungs.

Chemistry

Inexpensive Models for Demonstrating Molecular Structure

By PAUL WESTMEYER, Instructor in Education
University High School, University of Illinois, Urbana

When my high school chemistry class began the study of organic chemistry and saw some of the complicated formulas, some of the students really became interested in trying to understand molecular structure. One student came to me after class and asked if we had "one of those sets used to make molecular models." I said that we didn't, but that I was sure we could find a substitute. Just the day before I had obtained a large number of corks in assorted sizes from the storeroom and these came to mind. I said perhaps we could use corks of various sizes to represent the atoms and toothpicks to hold them together and to represent the bonds.

We sorted out corks of three sizes. The student dyed the medium-sized ones black to represent carbon and some larger ones red to represent oxygen. We left the smallest ones plain to represent hydrogen atoms. Using toothpicks pointed on both ends, the corks can be strung together easily and quickly to represent almost any type of molecule. Double bonds are easy to show and ring compounds present no difficulty. Best of all, these models cost but little—corks and toothpicks are reasonably cheap!

General Science

A Problem-Solving Demonstration

By ARTHUR W. SMITH, JR., Plainfield, New Jersey, High School

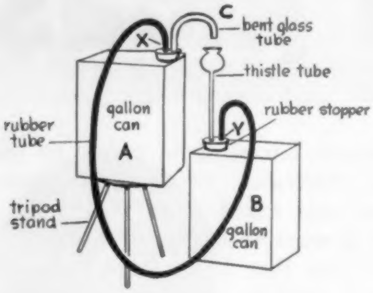
I should like to share an idea which I have found works very successfully as an "opener" for my ninth-grade general science classes. It is an exercise to get across the concept of *the use of the scientific method in solving problems*.

There were three major objectives about which I was concerned:

1. To try to create as much student interest at the start of the general science course as possible.
2. To demonstrate first hand how the scientific method operates.
3. To "feel out" the students (to see who knows what, to see how as individuals and as a group they operate to solve problems.

As soon as administrative details were finished on the first day of school, I pulled up from behind

the demonstration table the following set-up and called upon everyone to watch carefully what happens.



In the above apparatus, care was taken to have the rubber hose at points "x" and "y" completely covering the glass tubes. (Details as to what is inside the cans is presented in a later paragraph of this account.)

I filled a large beaker with water from the faucet and began to pour it into the thistle tube.

When the beaker was about half empty, a red colored liquid flowed up through the bent glass tube (c) and poured into the thistle tube. I then stopped pouring water from the beaker. The flow of red liquid from can A to can B continued uninterrupted for about fifteen minutes.

Students were allowed to come up and carefully look at the apparatus while the red liquid was flowing from can B, but *no one was allowed to touch.* After everyone had a good look at what happened an assignment was made for the students to *write out their observations* and *as a result of these observations to try to figure out the "why" of this demonstration.*

The next day the students were called upon to give their observations as to what happened. At this point the discussion was directed along the lines of accuracy of observation and accuracy in reporting correct sequence of observations. After the class agreed upon the observations they were called upon to present their "ideas" in explanation of what happened. (The term "hypothesis" was taken up later.) Each student was encouraged to contribute, even the students who were "sure their solution just couldn't be right." The ideas were discussed and challenged by different members of the class. As a result many were rejected and the class seemed to agree upon those which could be possible. The two ideas which received the greatest support were as follows:

1. Some sort of chemical action took place in cans A or B to change the color of the water and to force it out of can A.
2. Can A contained a red liquid to start. When water was poured into can B, air was forced out of B which in turn forced the colored liquid out of can A.

Both of these ideas seemed feasible to different members of the class. The question was then asked how they could find out for sure. Someone suggested that the demonstration be repeated. It was. They watched carefully, but soon realized that they could go no farther until the contents of the cans were examined. I then allowed some students to come up and remove the stoppers and examine the contents of the cans.

Can A was found to be filled nearly to the top with a red liquid (Tintex dye in water). The bent glass tube (c) extended to the bottom of the can. Can B was found to be "empty." (After discussion it was brought out that it was full of air—but no liquid.)

With this new information the discussion proceeded more rapidly. Idea #1 about the chemical reaction was discarded. Idea #2 about the water which was poured into can A forcing air out of the can through the hose and into can B to force the red liquid out was developed. The question now was: "While this idea seems good, how can we be sure?" "How can we test this idea to see if this is what really happens?"

Ideas for experiments were not long in coming. Each idea was subjected to experimentation. The following two simple tests proved very convincing:

1. To prove that air will force the liquid from can A was shown when a student disconnected the hose at point "y" and blew through it into can A.
2. To prove that when water is poured into can B air is forced out was shown when a student filled a pan with water to see if bubbles were formed when water displaced the air in the can.

After the solution of this problem was worked out, attention was directed toward the steps followed in arriving at the solution of the problem. It was pointed out that, whether the students knew it or not, they were following the steps of the scientific method in solving their problem. What were these steps?

1. Observations
2. Developing hypotheses as a result of these observations
3. Discussion and evaluation of these different hypotheses (sharing ideas)

4. Obtaining more accurate observations (demonstrated by closer examination of the apparatus)
5. Formulation of new hypothesis as a result of new information gained
6. Experimentation to test hypothesis

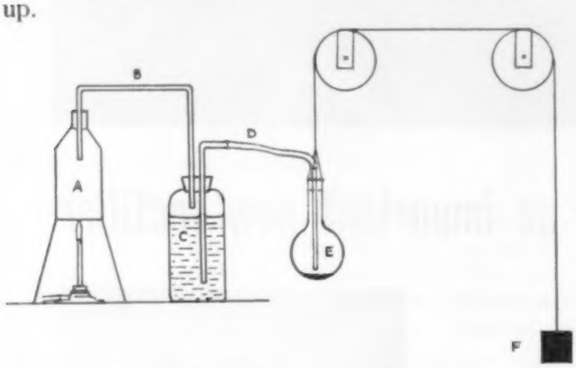
Thus, with this exercise in which the students actually work out a problem by using the scientific method, it was possible to effectively present concepts of hypothesis, theory, principle, law, etc. And what was probably even more important, *the class got off to a good start in which there was very high pupil interest.*

Physics

Hero's Heat Engine

By THOMAS P. BENNETT, Winter Haven, Florida, High School

Hero's heat engine, one of the early applications of converting heat energy to mechanical energy, can be effectively demonstrated with the following setup.



"A" is a metal can with a one-hole stopper which has a piece of glass tubing, "B," running from it to a bottle, "C." The bottle is filled three-fourths full of water. "D" is a piece of rubber tubing, which serves as a siphon, running to a small flask, "E." The flask is connected, as shown, with the resistance, "F," using a series of pulleys. The mechanical advantage can be regulated to any desired amount. (The illustration shows but a change in direction.)

When the air in "A" is heated it expands and flows through "B" into "C." This produces an increase in pressure on the water in "C" causing water to flow through "D" into flask "E." The added weight of the water causes the flask to move down, which in turn causes the resistance to move up. When "A" cools, water by the reverse process flows from "E" back into "C."

NSTA Activities

Atlanta Meeting

The 1955 combined meeting of the AAAS Science Teaching Societies will be held at the Dinkler Plaza Hotel, Atlanta, Georgia, December 27-30. Included are ANSS, NABT, NARST, and NSTA. It is hoped that printed programs can be mailed to members of the societies in at least the southeastern states prior to the meeting. The program of joint sessions and individual sessions of NSTA follows.

Tuesday, December 27

8:00 a.m. Presentation of Science Teaching Films

9:00 a.m. Joint Session (arranged by ANSS): *Southern Agriculture from 1913 to 1956*

2:00 p.m. NSTA Concurrent Session A:

1. *This Is Your NSTA*
2. *Attracting Secondary Students into Science*—demonstration lectures in five areas of the physical sciences

3:00 p.m. NSTA Concurrent Session B:

1. *This Is Your NSTA*
2. *How Can We Develop Continuity in the Elementary Science Program in Order to Eliminate Repetition and Gaps?*—panel leader and four discussants

8:00 p.m. Joint Session (arranged by NSTA): *New Frontiers in Research*

9:00 p.m. Entertainment: *A Christmas Interlude* (arranged by Atlanta Science Teachers Club)

Wednesday, December 28

8:00 a.m. Presentation of Science Teaching Films

9:00 a.m. Joint Session (arranged by NABT): *Science and Human Resources*

2:00 p.m. Joint Symposium (arranged by NARST): *Recent Research in Science Education*

8:00 p.m. AAAS Presidential Address

9:00 p.m. AAAS President's Reception

Thursday, December 29

9:00 a.m. Special Session with AAAS: *The Crisis in Science Education*

2:00 p.m. NSTA Concurrent Session A: "Here's How I Do It"—*Arriving at a Grade in Multiple Ways*—five panelists plus summarizer

3:00 p.m. NSTA Concurrent Session B-1: "Elementary Science, Kindergarten through Third Grade"—*Effective Use of Science Demonstrations for Improved Learning*—four presentations

3:00 p.m. NSTA Concurrent Session B-2: "Elementary Science, Fourth through Seventh Grades"—*Effective Use of Science Demonstrations for Improved Learning*—four presentations

Friday, December 30

9:00 a.m. Field Trip to Granite Outcrops (sponsored by ANSS and NABT; co-sponsored by NSTA)

9:00 a.m. Field Trips to Atlanta Industries and Laboratories (sponsored by NSTA; co-sponsored by ANSS and NABT)

New Life Members

Please see page 316 for new additions since the last listing in the April, 1955 issue.

Fourth National Convention

The Fourth National Convention for all teachers of science, being planned by NSTA, will be held March 14-17, 1956, at the Shoreham Hotel in Washington, D. C. With sessions for teachers in elementary schools, junior and senior high schools, and colleges, it is expected that 1500 will attend the convention. Convention theme is *Problem-Solving: How We Learn.* Sessions and program elements are as follows. Anyone interested to be a program participant is invited and urged to write to the chairman of the planning committee, Mr. Henry A. Shannon, State Department of Public Instruction, Raleigh, North Carolina.

Wednesday, March 14

10:00 a.m. NSTA Business-Industry Section: *Annual Business Meeting*

1:00 p.m. Registration opens

2:00 p.m. Meetings of NSTA committees

2:00 p.m. Showings of science teaching films

2:00 p.m. Tours of Washington (available)

4:00 p.m. Informal, get-acquainted hour

5:00 p.m. Dinner meetings—science supervisors, Junior Academy sponsors, others

8:00 p.m. First General Session; address: *The Learning Problem*

Thursday, March 15

"Learning How to Find Out"

8:00 a.m. Exposition of Science Teaching Aids

9:00 a.m. Concurrent General Sessions

- **A.** Elementary; address: *Helping Children Learn How to Find Out*
- **B.** High School and College; panel discussion: *Helping Young People Learn How to Find Out*

10:45 a.m. Work-Discussion Groups

- **A.** Elementary (four groups)
- **B.** Junior High (six groups)
- **C.** Biological Sciences (six groups)
- **D.** Physical Sciences (six groups)
- **E.** College (four groups)

12:15 p.m. Luncheon meetings—NSTA life members, state groups, others

1:30 p.m. Exposition of Science Teaching Aids

2:30 p.m. Concurrent Groups

- **A.** Elementary; work-discussion groups (four)
- **B.** High School and College Symposia
  1. Using Case Studies and the Historical Approach
  2. Developing Problem Situations for Learning
  3. Problems for Rapid Learners
  4. Science Facilities for Problem-Solving
  5. Educating Teachers for Problem-Solving

4:00 p.m. Exposition of Science Teaching Aids

8:00 p.m. General Session; brief reports: *This Is Your NSTA-NEA-AAAS*

9:30 p.m. Reception

Friday, March 16

"Finding Out What Nobody Knows"

8:30 a.m. Travel to D. C. area schools and laboratories

- **A.** Elementary—school visitation and observation
- **B.** Elementary, high school, and college—visitation and interview-tours of laboratories
  1. National Bureau of Standards
  2. National Institutes of Health
  3. Naval Ordnance Laboratory
  4. Naval Research Laboratory
  5. Agricultural Research Center, Beltsville, Maryland

11:30 a.m. Lunch at schools or laboratories

1:00 p.m. Travel to hotel

1:30 p.m. Exposition of Science Teaching Aids

2:00 p.m. Concurrent Sessions

- **A.** Nature of Research in the Biological Sciences
- **B.** Nature of Research in the Physical Sciences

4:00 p.m. Exposition of Science Teaching Aids

7:00 p.m. Annual Banquet; address: *Science in Human Affairs*

Saturday, March 17

"Finding Out What We Have Learned"

8:00 a.m. Exposition of Science Teaching Aids

9:30 a.m. General Session; address: *Evaluation in Relation to Problem-Solving*

10:45 a.m. Concurrent Groups

- **A.** Elementary; address: *Improvising Simple Learning Materials*
- **B.** High School and College; panel groups
  1. Junior High
  2. Biology
  3. Chemistry
  4. Physics

1:30 p.m. Concurrent Groups

- **A.** Elementary—*Here's How I Do It*
- **B.** High School and College—*Here's Why I Do It*
  1. Junior High
  2. Biology
  3. Chemistry
  4. Physics

6:00 p.m. First Meeting of General Planning Committee for the Fifth National Convention, to be held in Cleveland, Ohio, March 20-23, 1957

4TH NATIONAL CONVENTION OF NSTA

The National Science Teachers Association has demonstrated effective and intelligent leadership in improving science teaching in the United States. But the NSTA is not alone in having this interest. The American Association for the Advancement of Science and many of the other scientific organizations of the country consider the improvement of science and mathematics teaching to be one of the country's most important educational and social problems. The problem is of concern to teachers, industry, scientists, and indeed everyone interested in the welfare of the nation. Working together we can undoubtedly accomplish more than any of us can do alone. The AAAS therefore welcomes the opportunity to cooperate with the NSTA, and is looking forward to participation in the Fourth National Convention of the Association.

Dael Wolfle, *Administrative Secretary*
American Association for the Advancement of Science

The forthcoming convention of the National Science Teachers Association is a highly significant occasion to those concerned with the conduct and support of medical research. The future of science in America depends in large measure upon the quality and quantity of science teaching. And just as science needs the teacher, so may the teacher benefit by frequent contact with the scientist, for in the last analysis he is less concerned with teaching facts than with imparting a *spirit*. The Association will convene in Washington, D. C., which has become an important research center and offers rich opportunities for a vital teacher-scientist reunion. We at the National Institutes of Health research bureau of the Public Health Service, cordially invite the members to our laboratories and clinical facility on March 16. We anticipate a mutually rewarding visit by those whose mission is to lead talented youth into the life of "finding out what nobody knows."

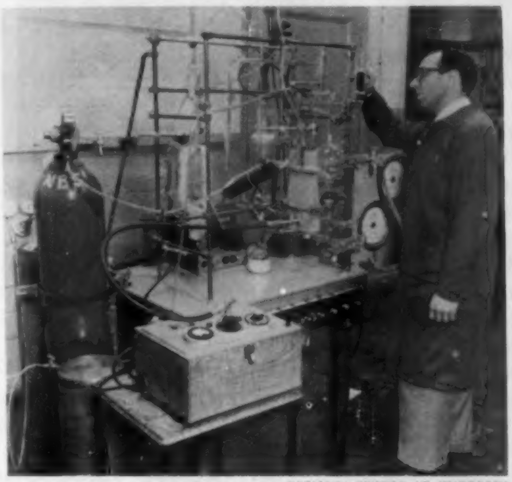
James A. Shannon, *Director*
National Institutes of Health

All of us at the headquarters of the National Education Association have watched with pride the growth of the National Science Teachers Association, one of our NEA departments. The NSTA has firmly established itself as one of our profession's major organizations. This position is amply justified by the wide range of NSTA activities and services, one evidence of which is your National Convention here in Washington.

To be sure, education in science is but one segment of the total educational endeavor; but with science becoming an ever-increasing factor in our lives, the role of the science teacher likewise becomes increasingly significant. And in view of the need to develop fully the abilities of the nation's more able youth, the NSTA is to be congratulated on the program of its Future Scientists of America Foundation.

On behalf of the NEA, it is a pleasure to welcome NSTA members and friends to Washington. We look forward to sharing in some of your convention activities. And before you go home, do find time to visit your new NEA Educational Center. You'll be mighty proud of it!

William G. Carr, *Executive Secretary*
National Education Association



NATIONAL BUREAU OF STANDARDS

Turbine blade failure and "flame-out" in modern jet engines emphasize the lack of basic information on temperature measurements. One of the objectives of the NBS high-temperature laboratory is to obtain basic data required for more efficient and safe use of all high-temperature engines, from jets and gas turbines to rockets.

A cordial invitation is extended to members of the National Science Teachers Association to visit the National Bureau of Standards during their Fourth National Convention. The theme of the convention, "Problem-Solving: How We Learn," is particularly pertinent to our program. You as science teachers are already well aware that work in scientific standards and measurement represents a cornerstone of scientific and industrial progress. The Bureau's work in this area ranges from improving the precision of basic standards of the classical type to developing the new standards and measurement techniques required in such areas as radar and atomic energy. The success of NBS scientists in solving these new and complex problems lies in the cooperative effort of physicists, chemists, mathematicians, and engineers working together at the frontiers of knowledge.

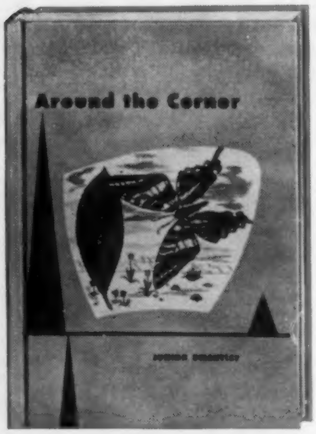
A. V. Astin, *Director*
National Bureau of Standards

WASHINGTON, D. C.

MARCH 14–17, 1956

Announcing...

A Child Progress Plan for Elementary Science



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FSA Activities

Science Achievement Awards for Students

From time immemorial, the thrills of discovery and invention have provided the allure which brings people into the scientific enterprise. In turn, no discovery or invention reaches its full value until the person with the idea explains it clearly to other interested people. These two points, basic to the philosophy of the Awards program, are reflected in the new booklet, *If You Want to Do a Science Project.*

These two points of philosophy have also played an important part in planning and conducting this program. Any student in grades 7 through 12 can take part. Any activity that parallels or is similar to what scientists do can constitute a project. A minimum of time must be devoted to preparation of the entry. It is not necessary to prepare an exhibit or display of the project, although many additional values are gained by doing so. An entry becomes more like the report that a practicing scientist would send "upstairs" to his group leader or laboratory director.

Doing the background study necessary to make a collection, designing or building a piece of necessary equipment, modifying a laboratory exercise, testing a product or process, and simply exploring anything that has aroused curiosity can lead to worthwhile student projects.

Remember that there have been four important changes in the program for 1956.

1. The deadline date has been moved up to March 15.

2. Twenty national awards of $100 Savings Bonds have been added for projects at any grade level dealing with metals and metallurgy.

3. Any kind of project is eligible for participation in any grade.

4. The total value of awards has been practically doubled.

FSA Chart-Making Contest

The methods of science continue to be talked about but much more must be done before many teachers can add the "do and feel" to the "see and hear" concept of science. Hoping to gain one more step in this direction, the 1956 FSA Chart-Making Contest is focused entirely on the theme—"What scientists do, how they do it, and why their work is important." The prizes this year are $25 worth of books to be chosen by the winning students or their science classes. Thirty awards will be divided between the junior and senior high school divisions. The complete rules follow.

1. Each chart should try to answer one or more of these questions—What do scientists do? What methods do they use? Why is their work important?
2. Charts should be 24 by 36 inches. Do not use stiff board. Entries must be rolled and wrapped securely for mailing. Include postage if charts are to be returned after contest is over.
3. An entry may be the work of a single student, small groups, or it may represent an entire class project. Students in grades 7 through 9 will compete with each other and similarly for students in grades 10 through 12.
4. Identify each entry on back of chart with name, school address, and grade of one student who is mainly responsible for the entry. The teacher's signature should appear there also.
5. Entries may be submitted as soon as ready. No entries will be accepted if postmarked later than March 1, 1956.
6. Send all entries to the Future Scientists of America Foundation, The National Science Teachers Association, 1201 Sixteenth St., N.W., Washington 6, D. C.
7. Winners will be announced on or before April 1, 1956. Award books may be selected from the 1950 through 1955 lists of Recommended Young People's Books published by the *Library Journal.*

Summer Programs for Teachers

Although all details have not been completed, the Foundation will make an active effort to help teachers with their 1956 summer plans for science-related jobs in industry, research assistants on university campuses, or participation in special conferences. It is not too early to register your hopes and preferences. Send us your name, major subject and the number of semester hours preparation, number of years teaching experience, non-teaching science related experience, if any, and geographical limitations or preferences.

One assured program is a 1956 West Coast Science Teachers' Summer Conference. For the third straight year, the Crown Zellerbach Foundation has given FSAF a $10,000 grant for this purpose. The 1956 Conference will be held at Oregon State College, June 15-29. Fellowships of $200 will be awarded to thirty-two teachers from the seven most western states. Application forms available from FSAF.

Book Reviews

BIOLOGY FOR YOU. B. Bernarr Vance and D. F. Miller. 652 pp. $4.20. J. B. Lippincott Company. Chicago, Illinois. (Third Edition) 1954.

The third edition of this popular biology text follows the recent trend of changing to a two-column format. Portions of the previous edition have been brought up-to-date with recent developments and changes. New material is included on medicine, drugs, and gardening.

The book is organized around fifteen units, each of which is quite complete in itself. It is thus possible to vary the sequence of teaching topics in order to meet the needs of special courses or different groups of students. The topics dealt with are the usual ones generally presented in high school biology. Each opens with an interest-provoking story, an item of biological history, or an account of some biological activity. In many places everyday experiences are tied in with new knowledge. Within each unit is a series of review questions following the major divisions of each unit. Each unit concludes with a unit summary and a unit review.

The activities and laboratory experiences suggested are all ones that can be done with a minimum of equipment. This means that students in every school should be able to engage in the suggested activities no matter how meager is the available equipment.

There is an extensive glossary and the book is well indexed. Teachers using this book as a basic textbook in a general biology course will probably find it very adequate for the student of average ability, somewhat too difficult for the slow learner, and somewhat lacking in challenge for the more able student.

RICHARD H. LAPE
Amherst Central High School
Snyder, New York

PRACTICAL PHYSICS. Marsh W. White, Kenneth V. Manning, and Robert L. Weber. 484 pp. $5.50. McGraw-Hill Book Company, Inc., New York. (Second Edition) 1955.

This book is intended to be used as an elementary text in one-semester physics courses presented in Junior Colleges, Technical Institutes, and Liberal Arts Colleges. The conventional fields of physics are covered in a concise manner without going into the greater detail which would be needed for students intending to continue in physics. Some twenty-four pages are devoted to atomic and nuclear physics. Directions for performing thirty-three simple experiments are included at the end of the text material.

A pleasing feature of the book is the generous number of illustrative solved problems which is provided. In these the algebraic treatment of units is emphasized. Each chapter is followed by a large number of problems, many of which include answers. Most problems make use of the British system of units; the metric gravitational system is not used. The mathematics required of the student is very simple. Formulas are generally stated rather than derived. Trigonometric functions are required for the chapters on force and motion and these are explained in the appendix. Tables of the trigonometric functions are included.

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Granby High School
Granby, Quebec

TV AND ELECTRONICS AS A CAREER. Ira Kamer and Richard H. Dorf. 326 pp. $4.95. John F. Rider Publisher, Inc. New York. 1951.

High school science students often have remarked to their instructor, "I am interested in electronics. What kind of opportunities exist in the field?" This book is a good beginning toward an answer as it offers a comprehensive overview of the field and covers job opportunities in television and radio in areas of design, operation, and sales.

The authors have not attempted the task by themselves. The chapter on television broadcasting was written by J. R. Poppele, of station WOR in New Jersey; the sections on electronic engineering, and radio and television manufacturing by Raymond W. Peterson of the Admiral Corporation; and the unit on television servicing by W. Hollander Bohlke of RCA Service Company, Inc. All are highly capable men in their field.

Job descriptions are complete yet concise. One should remember that this book was first published in 1951 when reading the salary schedules published within its pages. These may be unrepresentive of present schedules. That the book is somewhat dated is also noticeable in the section where parts needed for stocking a repairman's supply are listed. Further, there is no mention of the newer larger size picture tubes. Color television and the opportunities opened within this field are not mentioned.

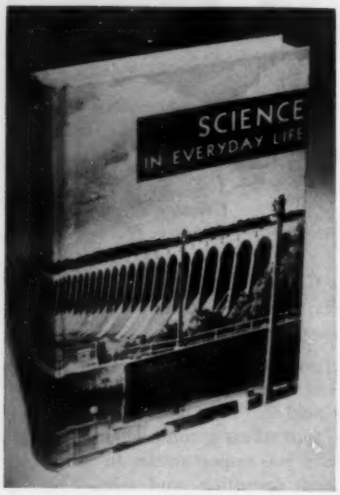
WILFRED H. HUPP
Marion-Franklin High School
Columbus, Ohio

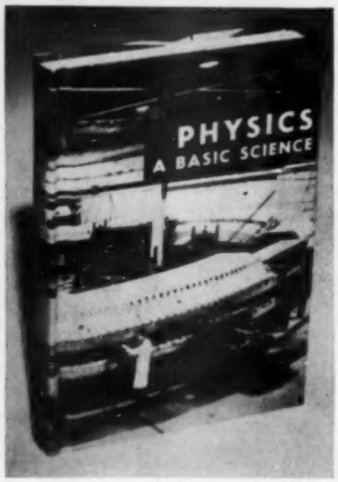
NEW WORLD OF CHEMISTRY. Bernard Jaffe. 678 pp. $4.16. Silver Burdett Company. New York. 1955.

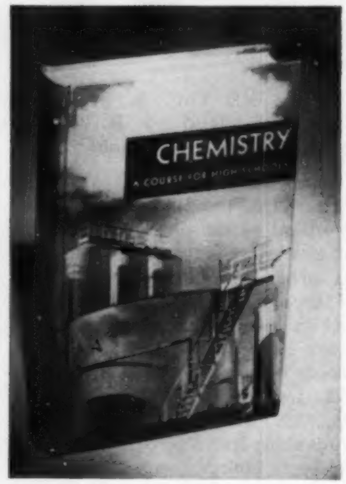
First published in 1935, this text for high school chemistry was well received. The 1955 edition has been extensively revised and new material added though the book as a whole has been shortened. Entirely new illustrations have been used and the diagrams redrawn and enlarged. "Striking advances have been made in nuclear energy, petrochemistry, metallurgy, textiles, and plastics. The chapters dealing with these subjects have been thoroughly revised to take these changes into account." The author, an outstanding teacher, is a strong advocate of the historical approach to teaching chemistry. His conviction is evident in the beginning of each chapter. This book is a good standard text made better by the revision.

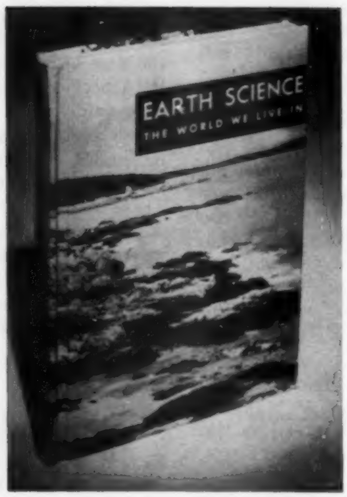
G. BRUCE HOOPER
Cuyahoga Heights High School
Cleveland, Ohio

Working Out of the T-Formation









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TREE FROG. Paul McCutcheon Sears. 48 pp. $2.00. Holiday House. New York. 1954.

Paul Sears traces the life history of the tree frog from the fitful wakening of spring following hibernation through food gathering and the perils of existence to mating, egg laying, growth, and digging in for winter. He uses a delightful manner that makes the reader care about the tree frog, but which is factual and solid throughout. The charming, thoroughly original drawings by Barbara Latham that enhance each spread, adhere closely to fact. This volume appeals to all ages from eight up—a standard that a good book for young people should meet.

FRANKLYN M. BRANLEY
State Teachers College
Jersey City, New Jersey

THE CARE AND FEEDING OF GARDEN PLANTS. 14 leading authorities of The American Society for Horticultural Science. 184 pp. $3.00. American Society for Horticultural Science and National Fertilizer Association. Washington, D. C. 1954.

This is really an outstanding book for the home gardener. In a brief but highly effective manner, the various experts have given the highlights of the culture of the plants in their special field of interest. They cover the average home gardener's interests surprisingly well.

Starting off with a brief but highly interesting discussion of how plants grow, they cover lawns, shrubs, trees, house plants, garden flowers, vegetables, and small fruits in seven other chapters.

While the book is slanted toward the nutrition and fertilization of plants, a tremendous amount of other valuable cultural information for the home gardener is given simply and concisely.

Outstanding and unique features of the book are the numerous color plates showing the appearance of the foliage of various plants when there are deficiencies in the various soil minerals. These are of great value in helping the gardener to decide what his soil needs when crops show abnormalities of leaf coloring—telltale signs when you know how to interpret them.

The book is an invaluable reference and guide for the gardener in the care and feeding of his plants, and many biology and chemistry teachers will want it for their student reference shelf.

PAUL R. YOUNG
School Garden Supervisor
Cleveland, Ohio

ALL ABOUT WHALES. Roy Chapman Andrews. 148pp. $1.95. Random House. New York. 1954.

The thrill of adventure along with scientific facts about whale hunting and whales are interestingly portrayed from the author's personal observations and studies. Youngsters will feel the thrill of the "hunt," the suspense of the action, and also be well informed as to the many varieties of whales. The book should add variety and interest to several types of units such as the study of mammals or the whale industry. The format and blue-white illustrations are encouragements to enjoyable reading.

CHARLOTTE A. BABCOCK
Conqueror's College
Portland, Oregon

Audio-Visual REVIEWS

CURES AND COLDS. 52-frame filmstrip, 1955. Color. Available free from the Audio-Visual School Service, 48 E. 29th St., New York, N. Y. Sponsored by the Pfizer Laboratories.

Recommendation: Suitable for intermediate and junior high school levels in science and health.

Content: This filmstrip is intended to familiarize the students with some of the important steps in the advance from magical notions of medicine to the scientific approach to medicine. It is arranged according to the main historical events which are generally regarded as important milestones in the history of medicine.

Evaluation: The filmstrip is done in a cartoon technique. It was not felt to be too valuable for most science units. The organization was not good, and very little true science seemed to be incorporated. At times it was hard to determine what the cartoon represented. A Teachers' Guide is included.

WORLD OF LITTLE THINGS. 15 min. sound, 1954. $120 Color, $60 B & W. Moody Institute of Science, 11428 Santa Monica Blvd., Los Angeles 25, Calif.

Recommendation: Very useful in high school biology and in junior high units on Microscopic Life. May have limited use on the upper intermediate level.

Content: Typical minute metazoa and protozoa found in fresh water are seen. The relationship of plants and animals in a water-drop aquarium is explained. Members of the University of Southern California Marine Laboratory are shown conducting a marine life survey. Close-ups of various diatoms are shown, and the economic importance of diatomaceous earth is emphasized.

Evaluation: The photography is excellent, and the commentary, although a little above the level of lower grades, is good. The film has a fine musical score. It features the use of microphotography and time-lapse techniques. It should stimulate interest and discussion. The brief message included at the end of the film adds a note of dignity to the presentation. A Teachers' Guide is included.

NITROGEN CYCLE. 14 min. sound, 1954. $60 B & W. United World Films, 542 S. Dearborn St., Chicago, Ill.

Recommendation: Suitable for use in high school biology, general science, social studies, and agriculture on the junior high level.

Content: Shows that the air is the source of nitrogen that is utilized by the bacteria which invade plant roots and form nodules. The plant uses the nitrogen to form proteins used by animals. In the food chain these animals become food for other animals, and the excrement is finally returned to the soil by bacterial decomposition. Soluble nitrates are formed when the energy of lightning combines oxygen and nitrogen in the air. These compounds enter the soil and are also available to the plants. If natural methods are not sufficient, the farmer must add commercial fertilizers to enrich the soil.

Evaluation: The film has well-organized content and a good summary at the end. This summary, however, seems to be geared to a junior high level. Microphotography and cine-radiology show actual functions of the root hairs associated with the nodules and bacteria in the soil. Teachers' Guide is included.

SOUND: HARMONIC MOTION, PROGRESSIVE WAVES, TRANSVERSE WAVES, LONGITUDINAL WAVES. Series of four, nine-minute films. $180 series, or $50 each B & W. McGraw-Hill Book Co., Inc., Text-Film Dept., 330 W. 42nd St., New York, N. Y.

Recommendation: Suitable for high school and college physics and mathematics classes. Could be used both in sound and electronics.

Content: Various types of sound waves are graphically illustrated in each of the films. The title indicates the area which is treated. The films use diagrams, beads, springs, and other concrete objects to illustrate each point. The mathematical relationships between the waves and the resulting formulae are stressed.

Evaluation: Along with textbook study and classroom discussion, these films should prove extremely valuable in providing a complete coverage of the topic of wave motion. Since it shows by animated diagrams the actual wave progress, it supplies a visual aid which can hardly be illustrated in any other way. The commentary is good. Guide sheet for teachers is included. Produced under supervision of the American Association of Physics Teachers.

SIMPLE MACHINES (SERIES). Four films each 6 min. sound, 1954. $110 B & W. Coronet Instructional Films, Coronet Building, Chicago 1, Ill.

Recommendation: Suitable for supplementary work in science in intermediate grades, and for general science at the junior high level. Vocabulary may be too advanced for classes below grade four.

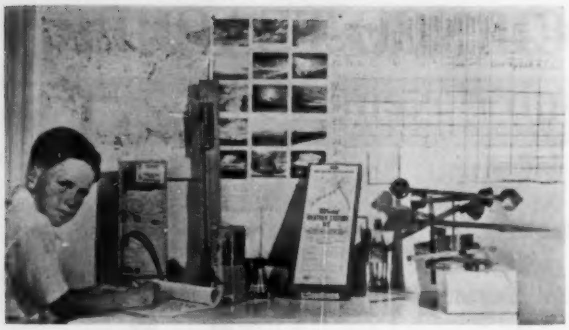
Content: This series has been planned to help pupils develop an understanding of the principles and operation of simple machines. The four films dealing with *Levers, Inclined Planes, Pulleys, Wheels and Axles,* provide an opportunity for demonstrating the operating principles of the machines, and for illustrating the ways in which they ease and simplify work. The films incorporate laboratory and model set-ups and animation to present a number of demonstrations of the basic relationships between force and distance.

Evaluation: Covers the basic facts and ideas although any well-equipped laboratory can duplicate the experiments easily. Content is well-organized. Photography and sound are good, but the presentation is quite academic. A Teachers' Guide accompanies the series.

Volume XXII, THE SCIENCE TEACHER

Index—February through November, 1955

Author's Index



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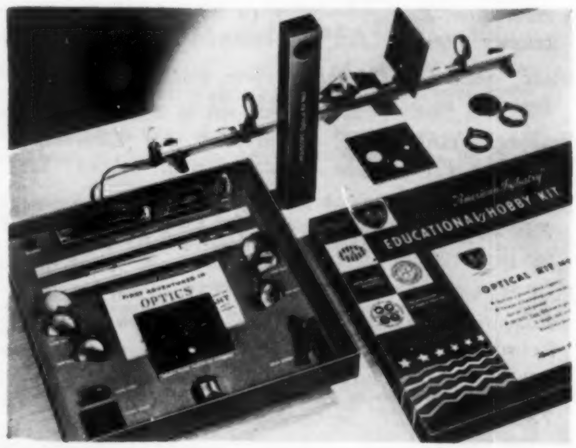

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NSTA Activities

Science Course Content, Organization, and Curriculum

Tests and Evaluation of Outcomes

NSTA Life Member Roster has reached 162, representing an increase of 32 percent since last October. Welcome to the following who have become life members since April, 1955:

AIELLO, ALFRED, North Royalton, Ohio
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BURNS, RICHARD F., Whitinsville, Massachusetts
CLINE, ERVIN L., Arriba, Colorado
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GURR, EDWARD M., Phoenix, Arizona
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